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TROPICAL CYCLONES OF THE EASTERN NORTH PACIFIC OCEAN

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Nearly all published works upon the cyclones of the Northern Hemisphere rather emphasize the statement that storms of the Tropics, except in the Arabian Sea and the Bay of Bengal, have their natural habitat only over the lower western waters of the great oceans. It is unfortunate that this supposition yet obtains in many quarters. The Indian seas have long held a unique position in this particular, that cyclones have formed indifferently east and west over their waters, while no other west-coast area north of the Equator has been connected generally with the cyclone history of the Tropics. Assuredly, then, it is time that a certain considerable area of the sea off the Mexican west coast, or the southeastern North Pacific, be definitely recognized in all meteorological publications as a place of dangerous summer and autumn cyclones, more especially since, with the opening of the Panama Canal in 1914, this region has sprung into increasing importance by reason of its waters being crossed by greater volumes of trade.

Region of occurrence.—Draw a line southwestward from Point Eugenia on the middle coast of Lower California to meet the tenth parallel of north latitude, in longitude 125° west, thence eastward to the Costa Rican coast, and with the intermediate land boundary for one side, there is inclosed in a rough triangle the principal part of the region affected by tropical storms. To be sure, cyclones sometimes form farther to the southward, sometimes extend their activities farther to the northward and eastward, and occur occasionally within a comparatively narrow belt running 30° or so to the westward of the meridian given as the western apex of the triangle, yet within the boundaries delineated they are exhibited to the fullest, and here the most of them have birth, progression, and dissolution.

Summer weather of this region.—The summer weather here is usually hot and humid. The normal wind circulation is light and more or less unsteady over a great part of the area. Calms are frequent in most portions, and conditions are as ideal for atmospheric overturnings as they are east of the Leeward Islands. In coastal localities the rainy season begins usually in June, except that it arrives considerably later over Lower California than along the coast proper farther to the southward. With October, precipitation generally begins to lessen.

The cyclone season.—The period of cyclone occurrence fairly well coincides with that of the general rains, but whether the wet season for any year begins earlier than June or not, there is little reason to expect a cyclone prior to that month. May had long been recognized as a month without such storms, but the existence of a moderate cyclone from the 24th to the 27th of May, 1928, to the southward of the Revillagigedo Islands, on the route between Panama and Honolulu, put an end to its record of entire immunity. With this exception, the earliest cyclones previously known formed a week or 10 days later in the season. There is an average occurrence for June of a trifle more than one in two years. In July and August there is a slight increase in numbers and activity, but September is preeminently the month of most frequent storminess of this character, about two-fifths of the entire number of cyclonic disturbances occurring then. In October they wane appreciably in frequency, though gaining slightly in intensity, and November adds only an occasional outburst—a violent one more often than otherwise—to close the activities of the season. After November there is only one record of a Pacific tropical cyclone occurring within 2,000 miles or so of the Mexican littoral. This is shown in the Mexican Climatological Atlas (1) in the track of December 22–26, 1925, where it appears as approaching nearest the coast below Cape Corrientes, at a distance of approximately 200 miles. Another December cyclone comes from the records of the Deutsche Seewarte (2) as occurring in 1832 southeast of the Hawaiian Islands. There is further record of a still later cyclone, one of January many years ago, but it does not seem to be sufficiently verified to permit of tabulation as such.

Northers.—Often, a month or two before the cyclone season ends, another class of frequently violent winds blows along portions of the west coast, particularly over the Gulf of Tehuantepec and to a lesser extent along the Central American shores. These, if exceptionally strong, are often called hurricanes, and might be mistaken for cyclones were it not that a study of their behavior shows them to be otherwise, for the region they most persistently haunt is also the most common breeding place of the coast cyclone. They are, however, anticyclonic winds, and, although known by various local names, are true northers. They last from a few hours to a few days, depending upon the period during which an excess of air piles up against the northern buttress of the Cordilleras from the Gulf of Campeche, whenever strong anticyclones from the United States extend sufficiently far across the Gulf of Mexico in fall and winter. The spill of this overpouring air down the opposite slope to the Pacific is sometimes so forcible that hurricane winds rage over the entire southern gulf and for some distance to the southward. A recent instance of one of these northers of considerable violence is that of the so-called hurricane of November 24, 1928, experienced by the U. S. S. *Maryland* during the good-will tour of President-elect Hoover. The gale usually blows seaward from a direction anywhere between east-northeast and west-northwest, and is frequently associated with a temporary slight fall in pressure.

Early history of the stormy weather of this coast.—During Sir William Dampier's voyages (3) in the late years of

the seventeenth century, he encountered many strong winds in this locality. For instance, when off Guatemala in September, 1685, he met with very bad weather, and in writing of it said that "seldom a day passed but we had one or two violent tornadoes."

Many interesting comments upon the wet-season weather of the coast from Guaymas far southward, ascribed to British and American naval officers early assigned by their respective Governments to the various harbors, are related by Findlay (4). All harbors in the days of sailing vessels were considered to be dangerous, owing to the frequent violent winds which might be expected, and to the accompanying heavy seas which were likely to drag a ship from her anchor and pile her upon a frequently rocky shore. Such gales came on with so little advance warning that a vessel might not be enabled to seek the greater safety of the open sea before they were at hand. In addition to these dangerous conditions that were likely to occur at any time, even harder storms might be expected, especially toward the end of the season, near or after the day of the Feast of Saint Francis, in October, when the west coast people looked for el cordonazo, the "lash of Saint Francis," a southerly hurricane that not only wreaked havoc among the fishermen's boats, but destroyed their houses as well, so that some villages due to the fear of it were deserted during the threatening months.

Among the earliest recorded destructive hurricanes of this coast were those of November 1, 1839, during which most of the 12 ships then in the harbor of Mazatlan were lost with their crews, and of November 1, 1840, during which three vessels were lost at San Blas. The other storms—"tornadoes" and violent winds—were probably for the most part heavy thunder storms and squalls of a local character, or they were northers of the autumn months. El cordonazo, while expected with apprehension annually, was thought not actually to occur much oftener on the average than once in six or eight years, whence the idea of its infrequency was handed down in meteorological history. The name applied most specifically to the strong southerly winds on the eastern sides of cyclones going up the coast. Gales from contrary directions were of course sometimes experienced, if the storm went inland, but, being comparatively infrequent, were not fixed upon by the popular mind.

Present-day observations show a far greater number of these dangerous on and off shore cyclones than were earlier hinted at, in addition to a considerable number of moderate to violent cyclones occurring too far at sea to affect the coast weather. All told, an average of five annually have been recorded during the last 19 years, with an extreme number of 13 for a single season.

The cyclones of Redfield.—In 1856 William C. Redfield (5) traced a number of progressive gales and hurricanes for the Atlantic and Pacific Oceans. Thirteen tracks of storms occurring between 1842 and 1855 were drawn for the region lying between Mexico and the one-hundred and twenty-fifth meridian of west longitude, and another track was projected still farther to the westward, southeast of the Hawaiian Islands. One as drawn indicated that the cyclone had originated in the Pacific, but had moved thence into the Gulf of Mexico.

Cyclones of the Deutsche Seewarte.—For the 61 years, 1832 to 1892, the Deutsche Seewarte has a record of 45 cyclones for this region. A comparison of data in this record with that of Redfield indicates the possibility, though not the certainty, that two storms in the respective lists were identical. Some analysis of these cyclones appears in the summary to this article.

Later cyclones.—From 1893 to 1909, inclusive, sporadic mention has been made here and there of various storms, both far at sea and in coastal waters, but little attempt has been made as yet to gather or to coordinate the probably existent data concerning the cyclones of this period, although it is expected the material will form the basis of a subsequent study.

Cyclones of the 19-year period, 1910–1928.—For these years the writer has found his most valuable and prolific medium of information in the weather reports of seamen cooperating with the Weather Bureau. In no other region north of the Equator traversed by tropical cyclones have reports, received by mail, been more necessary to the furtherance of knowledge of such storms, and already, from this source alone, 85 distinct cyclones have been isolated for these waters for the period given. Nor can the known list be yet considered as complete, if one may judge from the numbers recently added to it because of information received from vessel masters who, noting the growing interest in the subject, have forwarded copies of logs descriptive of cyclones experienced in earlier years. Often the only information regarding a storm has been drawn from the report of a single vessel that merely happened, as may be said, to encounter it. Were these waters even sparsely dotted with island radio reporting stations such a condition could by no means be as true. To be sure, radio must play no unimportant part in broadcasting storm information, yet withal it is only of late that it has seemed to be of distinct advantage in this interesting locality.

Cyclones traced by the Mexican weather service.—Another and a highly important factor must now be taken into consideration as a source of information about the storms of this coast. In a letter of February 19, 1925, to the writer, Prof. Pablo Vazquez Schiaffino, then chief of the meteorological observatory at Mazatlan, Sinaloa, Mexico, and now chief forecaster of the weather service, spoke of the difficulties often experienced in detecting and forecasting the presence and movements of these storms. It is of interest to quote in part from his communication:

> I would very much like to furnish information of many of these storms which have occurred during the past 40 years, but I have failed, since there are no records of meteorological information in the various ports of this coast to depend upon. I have searched in Acapulco, Manzanillo, and San Blas in the files of the old capitanias de puerto (captains of the harbor headquarters), and although in some cases was lucky to find reports of vessels that were taken by storms on sea and also observations and notes made by the captains themselves, it was all a mixture of data * * * from which nothing could be properly used, be it to plot the track of a storm or to appreciate its magnitude * * *. In this observatory we have very reliable records of weather observations since 1880, the study of which makes me believe that not less than 70 tropical storms have occurred and passed near or far from Mazatlan during that period, but * * * it is uncertain if not impossible to determine the direction of the trajectory, how far it passed from Mazatlan, etc. Since 1920 the Mexican Weather Bureau took control of the meteorological observations on both coasts * * * (and) we count in this coast, with nine stations equipped with all the principal instruments to make observations * * * a real meteorological service started; and with this observatory as a center * * * we are now able to forecast and follow the storms when they come from the south and more or less parallel to the coast and near enough to detect them, but when they come from the SW. or WSW. it is very difficult to make a forecast, plot the track, or locate the center. Sometimes the storms move parallel to the coast, but very far from it; in this case all the harbors experience heavy south sea swell and backing of the wind to SE. or E., but it blows only with gentle or moderate velocity. This I have observed in November and December, and once up to January, and it would not surprise me to know that ships en route to Panama from San Francisco, hundreds of miles west of the Mexican coast, have encountered storms of tropical characteristics during the winter months.

It will be seen from the foregoing that for the last eight years the Mexican Government has been enabled to make a much more specialized study of these cyclones than formerly, with the result that, although there is no record on its charts of a considerable number of the disturbances plotted by the Weather Bureau for the same time, it is in possession of information concerning a number of cyclones of which this office has no other knowledge. For instance, the recently available publication, Atlas Climatologico de la Republica Mexicana, 1921–1925, lists some 10 cyclones for those five years in addition to the 28 noted on our list for the same period. This office has no information as to the violence of any 1 of the 10, but wind and pressure reports are available for the other 28, of which 11 were of an intensity sufficient to give them hurricane or near-hurricane winds. These 10 added to the 85 otherwise identified for the 19-year period raises the known number to 95, or an average of at least five annually, with the number growing as new sources of information become available.

Chart of storm tracks.—The accompanying chart (fig. 1) shows the approximate tracks of 18 selected cyclones of this region, largely plotted from observations mailed by seamen to the Weather Bureau. The tracks numbered I to III are taken from early issues of the pilot charts.

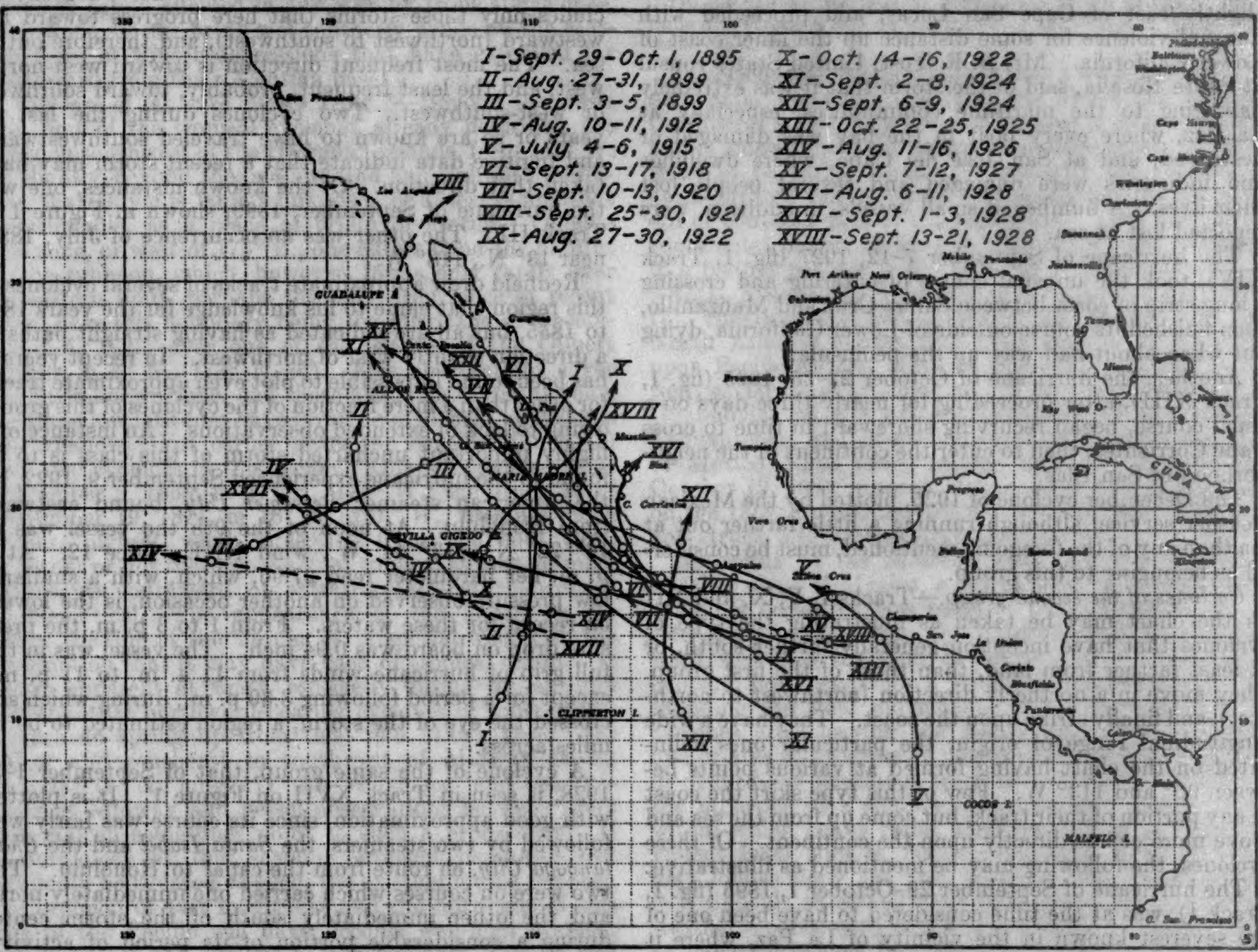

FIGURE 1.—Tracks of some representative tropical cyclones of the eastern North Pacific

CLASSES OF CYCLONES

The cyclones of these waters may be assembled, according to place of origin and direction of progression, into four major classes or groups, though it will be realized that some members of each will naturally partake of characteristics belonging more especially to a neighboring group or groups. Generally speaking, also, it will not be found that the cyclones of a particular month are likely to fall into a given group. Hence the classification relates largely to geographical, and little to seasonal, occurrence. Briefly, the groupings may be thus indicated:

First. The coastwise storms.

Second. Cyclones that run perpendicular to the coast.

Third. Cyclones of the Revillagigedo Islands.

Fourth. Cyclones west of the one hundred and twenty-fifth meridian.

Cyclones of the first group.—These may be near or moderately far from the coast, but usually over all or a greater part of the course they run roughly parallel to the land contour. Many of these have their origin near or somewhat to the southward of the Gulf of Tehuantepec, or between Salina Cruz and Acapulco. The Mexican atlas shows some as forming over Guatemala or the western

Caribbean. Unless these storms die out at an early stage, or go inland meanwhile, they usually follow a course that will take them across or slightly to the westward of the entrance to the Gulf of California, and therefore to one side or the other of Cape San Lucas. The region of greatest storminess, as a rule, lies between this cape and the latitude of Manzanillo, where the cyclones arrive at their highest degree of intensity. A few examples of this class may be mentioned.

A destructive hurricane of September 13–17, 1918 (fig. 1, Track VI), first reported west of Acapulco, ran slightly east of Cape San Lucas, and proceeded with unusual violence for some distance up the inner coast of Lower California. Mr. B. F. Yost, United States consul at Santa Rosalia, said of the storm that it was extremely damaging to the maritime communities, especially at La Paz, where every boat in the bay was damaged or destroyed, and at San Jose del Cabo, where dwellings and industries were damaged and several people lost their lives. A number of small vessels, in addition, were reported lost at sea.

The hurricane of September 7–12, 1927 (fig. 1, Track XIV), took the unusual course of entering and crossing a long strip of coast between Salina Cruz and Manzanillo, then finished its course outside of Lower California, dying out when about half way up the peninsula.

Another, the hurricane of October 22–25, 1925 (fig. 1, Track XIII), after proceeding for nearly three days on a usual course, began recurving shoreward in time to cross Cape Corrientes, then to enter the continent in the neighborhood of San Blas.

The December cyclone of 1925, plotted by the Mexican weather service, although running a little farther out at sea than any of the foregoing mentioned, must be considered as belonging to this group.

Cyclones of the second group.—Tracks I, V, X, and XII on the chart may be taken as illustrating the type of cyclones that have inception generally farther south, or at least farther from land, than those of the first group. They move in a northerly direction (northwest to northeast), and finally strike upon the coast. They have a wide longitudinal range of origin, the particular ones delineated on the chart having formed at various points between 90° and 113° W. Few of this type skirt the coast in any portion of their track, but come up from the sea and move more or less directly upon the continent. Of these cyclones, the following may be mentioned as illustrative:

The hurricane of September 29–October 1, 1895 (fig. 1, Track I), was at the time considered to have been one of the severest known in the vicinity of La Paz, where it caused considerable property damage and loss of life. It originated somewhat west and south of Clipperton Island, or near 10° N., 110° W., at which place strong southwesterly squalls were experienced by a vessel at anchor there on the 29th. The storm moved rapidly throughout its course, but during the forenoon of October 1 its speed must have been extraordinary, since the gales began off Cape San Lucas at a very early hour and the storm was at its height at Culiacan, Sinaloa, shortly after noon.

The moderate disturbance of July 4–6, 1915 (fig. 1, Track V), may be cited as the most southeasterly in point of origin of any plotted. Other cyclones have been found still farther south and east, but, with data confined to a single day's observation in a given case, not even an approximate track could be drawn. The one mentioned was first discovered well south of the tenth parallel, near the ninetieth meridian, and its course followed with fair certainty as it moved northward then northwestward toward Salina Cruz, near which port it entered the Mexican coast.

Cyclones of the third group.—Included in this division are such cyclones as occur largely near or to the southward and westward of the Revillagigedo Islands, a small group situated near 19° N., 111° to 112° W. Therefore, these storms may be met with, roughly, anywhere between 15° and 20° N., 110° and 120° W. Cyclones of the first group sometimes move into this field while on their way northward, or northeastward toward Lower California, but the third group, as differentiated, actually includes only those storms that here progress toward the westward (northwest to southwest), and therefore out to sea. The most frequent direction is toward west-northwest, and the least frequent, probably, toward southwest or west-southwest. Two cyclones during the last 50 years or so are known to have traveled southwestward, and fugitive data indicate that a recent storm may have taken that direction. Of the known instances, one was the hurricane of September, 1899, shown in Figure 1 as Track III. The other was an occurrence of July, 1882, near 13° N., 118° W.

Redfield drew approximate tracks of several cyclones of this region that came to his knowledge for the years 1847 to 1855, but all are indicated as having straight paths in a direction slightly west of northwest. In recent years it has been found impossible to plot even approximate tracks for other than a mere fraction of the cyclones of this group, owing to lack of extended observations. An instance of a highly important uncharted storm of this class is to be found in the hurricane experienced September 9, 1922, by the American steamer *Bessemer City*, bound eastward from Honolulu. At noon of the 9th the vessel was in 16° 22′ N., 113° 44′ W., wind NNE., force 12. At 3 p. m. her barometer read 27.96, which, with a similarly low pressure observed on another occasion, is the lowest on record for these waters. From 1 to 3 p. m. the pressure drop on board was 0.94 inch. The vessel was in the full grip of hurricane winds from 11 a. m. to 11 p. m., except for a period following 3.30 p. m., during which she crossed the eye of the storm, a region estimated to be 18 miles across.

A cyclone of the same group, that of September 1–3, 1928, is seen in Track XVII on Figure 1. It is plotted with good approximation, since its course was fairly well followed by two steamers, the *Santa Isabel* and the *Chattanooga City*, en route from the canal to Honolulu. The two were on courses which carried one immediately north and the other immediately south of the storm center during a considerable portion of its period of activity. It may be remarked that other cyclones have been similarly followed by vessels on this route, which indicates one of the principal sources of information for the storms of group 3.

Cyclones of the fourth group.—This includes all those somewhat rare—at least, infrequent—disturbances of low latitudes met with between longitudes 125° and about 155° W. Seven known summer cyclones have been allocated to this region, in addition to the December cyclone of 1832, located by the Deutsche Seewarte in 13° N., 148° W. Four formed in September and three in July or August. The "Cyclone of the Lark" was the name given by Redfield to the storm of September 23, 1843, observed in 15° N., 138° W. The cyclone of September 21–24, 1870, was traced westward by the Deutsche Seewarte from a position in 17° N., 141° W. Other cyclones were those of September 29, 1911, force 10, near 20° N., 147° W.; of July 21, 1926, lowest pressure 29.49 inches, in 19° N.,

131° W.; and of August 22–23, 1926, force 9, pressure 29.60, in 18° 38′ N., 125° 36′ W. Two cyclones in this field were encountered by one steamer, the *West Calera*, in 1925. The first was on July 31–August 1, near 15° N., 152° W., accompanied by strong northeast gales. From August 1 to 4 easterly gales occurred at Honolulu, although without appreciable barometric depression, the storm remaining well south of the islands. The second was that of September 27–28, near 22° N., 137° 30′ W. This was a hurricane of great depth, the barometer falling to 28.53 inches. It may be remarked that the Hawaiian Islands are very rarely affected in any way by tropical cyclones, their kona storms being wet southerly winds on the eastern sides of winter depressions that have extended far southward from their Aleutian base.

Cyclones of the "No Man's Land."—Beyond the western limit of the tropical cyclones already described lies a region southwest of the Hawaiian Islands, from 155° W. to slightly beyond the one hundred and eightieth meridian, that as yet is largely unknown, or at least somewhat questionable, as a place of origin of storms. Outside this zone, or west of 175° E., one enters upon the habitat of the typhoon, which, however, forms only rarely over its eastern limit, perhaps the only occurrence of recent years near this boundary being the hurricane of December 4–5, 1927, over one of the islands of the Gilbert Group, in 3° N., 173° E. (6). Few observations cover the little-known zone, and those available in recent years for these low latitudes have given no evidences of cyclonic disturbances. For earlier years the Segelhandbuch (2) lists two cyclones in this region. One was charted as of November 2, 1858, in 21° N., 174° W.; the other, as of November 19, 1874, in 16° N., 161° W., pressure 29.68 inches, highest wind force 10, from the southwest. Whether or not these were actual tropical storms, or mere extensions southward of extratropical disturbances, is problematical. The appearance of the latter, so far below the line of the Tropic, gives special weight to the assumption that it may have been of tropical origin. It seems apparent at times, especially during the autumn months, that northward-bearing cyclones of some consequence do spring up from this "No Man's Land" far below and southeast to southwest of Midway Island (lat. 28° 12′ N., long. 177° 22′ W.), since land observations at Midway and vessel observations between there and Hawaii sometimes point to such a probability. If disburbances of this seeming tropical character can assuredly be isolated as such, the existing hiatus between the typhoon of east longitudes and the hurricane of this side of the Pacific will have become well-nigh bridged. The range of the cyclone of the northern Tropics will then have become extended, with few slight lapses, from the eastern Atlantic westward across the intervening seas and narrow continental strips to Arabia.

West coast cyclones that cross to the Gulf of Mexico.—In Redfield's Chart of Gales and Hurricanes, 1855 (5), appears the track of a cyclone which sprang up from the southeastern waters of the Gulf of Tehuantepec, crossed lower Mexico to the Gulf of Campeche, thence moved northeastward across the Gulf of Mexico and Florida, and finally died out far east of Hatteras.

In 1924 Prof. P. Vazquez Schiaffino, then chief of the meteorological observatory at Mazatlan, sent to the Weather Bureau the tracks of two cyclones which occurred in September of that year. In a report upon the second of these storms (fig. 1, Track XII), which originated near 10° N., 102° 30′ W., on the 6th, and passed inland between Acapulco and Manzanillo on the 9th, he said:

> This cyclone followed a somewhat unusual path, since it is very rare for a cyclone from the Pacific to cross the Mexican Republic, as this one did. The cyclones that have previously passed to the Gulf of Mexico have crossed the Isthmus of Tehuantepec, but never to the west of the one hundredth meridian.
>
> Generally, when the direction of the path is like that of the present storm, from southwest to northeast, the cyclone disappears on reaching the land and encountering the foothills of the Sierra Madre, and only causes heavy rains and strong winds over a limited area.
>
> This storm gave torrential rains from Acapulco to Mazatlan and copious rains over the greater part of the Mexican Republic. At Acapulco the depth of rainfall was more than 100 millimeters (11.80 inches) in 54 hours. * * *
>
> On passing to the Gulf of Mexico the storm produced heavy rains and strong winds on the coasts of the States of Tamaulipas and Vera Cruz.

In considering the possibilities that a west-coast cyclone may enter upon the land and rise above the Mexican Cordilleras sufficiently intact to enable it to proceed and finally emerge upon the waters of another ocean, one finds them to be rather remote. Ordinarily the storm that heads inshore will break up completely against the western or southern face of the highlands. That part of the continental barrier of Mexico that offers least resistance to a further passage is the Isthmus of Tehuantepec.

C. L. Mitchell, in his study of West Indian hurricanes (7), covering the period 1887–1923, shows only two North Atlantic storms that originated in or bordering upon Pacific waters. One, in October, 1902, had inception, so far as data show, at the southern boundary of Guatemala, on the eastern extremity of the Gulf of Tehuantepec, and proceeded northward across the Gulf of Mexico. The other formed near 12° N., 92° W., October 12, 1923, entered Mexico at or near Salina Cruz on the 13th, crossed the isthmus and the Gulf of Mexico, and struck into southeastern Louisiana.

According to the Mexican atlas (1), and to certain weather maps of Mexico, a few cyclone tracks have been extended across various parts of the republic at a considerable distance from the isthmus, and thence eastward well into the Gulf of Mexico, since 1921. It is evident, however, from a study of the conditions surrounding the final movements of the remnants of the cyclones after leaving the Pacific that the continental line or area of progressive unsettledness is generally very ill defined, an enormous tract of country coming under the influence of a shallow, but wide-spread depression, within which heavy rains, accompanied by more or less violent local squalls, occur. Although rough weather may follow along the east Mexican coast at this time, it is difficult to establish its connection, through vessel weather reports, with such actual central Gulf depressions as have sometimes been seen to occur simultaneously. The latter are usually found to have an independent origin, so that their inclusion as a part of the Pacific cyclone track actually results in an amalgamation of two separate tracks.

A sea and land cyclone extraordinary.—Before leaving the subject of cyclones that go inland, it seems necessary to remark upon a most interesting and extraordinary occurrence—that of September–October, 1921, partly shown as Track VIII, in Figure 1. This cyclone ran from an apparent beginning off Acapulco, on a long sea route to above the thirtieth parallel. While yet half way up the western coast of Lower California—beyond which point very few of these cyclones go—it was still of considerable depth, a reading of 29.44 inches having been made by a steamer on the 29th. On the 30th the disturbance struck the coast as a weak depression and entered the semipermanent low-pressure area over southwestern Arizona, which at once developed great activity,

causing very heavy and damaging rains over a considerable area in the dry belt. The fall for the day in Yuma amounted to 3.63 inches. On October 1 the depression, clearly defined, moved eastward then northeastward, crossing the continent and entering the Gulf of St. Lawrence on the night of the 4th. It gathered energy east of Newfoundland on the 6th, but finally disappeared on the 8th near the twenty-fifth meridian west of the British Isles.

Length of cyclone tracks.—Except for those few storms whose courses, by reason of extensive observations, have been closely plotted with little error from known beginnings to known endings, the actual or even approximate lengths of tracks are in most instances problematical. Where paths have been drawn from few data covering two or three days only, over areas somewhat remote from the coast, further data, if obtainable, would undoubtedly result in extensions both backward and forward in date. But it is among the cyclones of the first group—those that are generally possible to be under observation for a lengthier period—that one must look for actual longest tracks. Preeminently, the longest track yet plotted is that of September–October, 1921, mentioned in the preceding paragraph, which, during more than two weeks of existence, covered a distance of approximately 6,000 to 7,000 miles. The shortest tracks may be found most probably among the cyclones of the second group that originate near or below the tenth parallel and disintegrate among the lower foothills of the land masses 500 or more miles to the northward. These also are probably most likely to move out of their usually restricted field in the Pacific.

Apart from these known progressive storms, one should not fail to make note of those areas of high wind velocity which sometimes occur coincidentally with barometrically depressed regions of considerable magnitude in coastal waters. At such times, while it is evident that strong cyclonic influences are at work, the observer is often unable to detect any regular progressive movement beyond that shown in an enlarging field of gale-swept waters. At other times, however, a marked intensification has been noted in one or two localized regions, a distinct vortex or two develop, and progression follows.

Storm diameter.—While the width of the gale area of these cyclones can not generally be known as closely as in a region like that traversed by the majority of Atlantic hurricanes, where there is a more widespread distribution of observations, yet it is evident that on the average they are much the narrower. Sometimes the actual affected path is 50 miles or less across it, with an extremely narrow central area swept by gales, either fresh or dangerous. Now and then, however, a cyclone of huge proportions is met with. That of August 27–31, 1899 (Track II, fig. 1), was more than 500 miles wide. That of September, 1921, while lying outside the entrance to the Gulf of California, strongly affected the coast 5° to 6° to the eastward, in addition to a distance unknown to the westward. The intense hurricane of September 9–10, 1922, with an "eye" diameter estimated by the steamship *Bessemer City* to be 15 or 18 miles, must have been of great width. This vessel, Honolulu to Panama, met the storm and entered its northwestern quadrant with a moderate gale early on the 9th, leaving it, when the gale abated 32 hours later, from the southeastern quadrant. During this time the steamer advanced only a few miles on her course, as she was forced backward for several hours of the 12 in which she was engaged with a full hurricane. The storm made estimated progress in excess of 10 miles an hour, and had a gale-swept width probably in excess of 300 miles.

Rate of progression.—Owing to the usually scattered condition of observations covering the cyclone field, positions for a given hour on any day or days are often only roughly to be approximated, yet some idea of speed may be obtained from many of the storms of this region, whence it appears that an average of 8 to 10 miles an hour is a fair estimate. The cyclone of September 7–12, 1927, averaged 12 miles, though during the first two days of its existence it made some 19 miles an hour. That of September 13–24, 1928, averaged between 7 and 8 miles an hour for several days, then, before recurving landward, suddenly abated its speed to between 2 and 3 miles.

Violence.—Beside those cyclones that are unquestionably of moderate intensity only, others of indeterminate strength occur—one merely knows they are cyclones, the violence of which, if the facts were known, might place many of them in the list of hurricanes. As it stands, about 34 per cent of all accredited cyclones are known to have developed whole storm to hurricane winds, which appear on the Beaufort scale as forces 11 and 12, and in miles per hour, from 64 upward. The winds in several instances have been estimated at from 100 to 130 miles an hour.

Lowest pressure readings.—The extreme lowest reading of atmospheric pressure recorded in any of these cyclones, and reported in two instances, was 27.96 inches. The first was read at 3 p. m., September 10, 1922, wind NE. by E., 12, on board the American steamer *Bessemer City*, near 16° 12′ N., 113° 44′ W. The second was made at 7.29 a. m., September 30, 1927, wind WSW., 12, on board the American steamer *President Hayes*, near 22° 02′ N., 108° 39′ W.

Seasonal extremes.—From our own record of 19 years, the earliest cyclone occurred on the 24th to 27th of May, 1928, maximum experienced force, 8 NW., lowest pressure 29.77, in 15° 20′ N., 107° 16′ W. The latest occurred November 10–11, 1925—a severe hurricane experienced by the Norwegian steamer *George Washington*, lowest barometer 28.15 inches, in 17° N., 102° W. The Mexican atlas has a still later cyclone, that of December 22–26, 1925, at some distance off the coast. These disturbances of late May, 1928, and of late December, 1925, may be taken as the authenticated extremes in point of season.

Longitudinal extremes.—Early in September of 1925, preeminently the cyclone year, cyclonic developments in the lower southeastern Tropics gave a southerly hurricane, pressure 29.78, on the 8th, in 4° 23′ N., 92° 13′ W. On the 13th, in 8° N., 85° W., fresh gales, with lowest pressure at 29.54 inches, gave undoubted indications of a cyclone, though further data concerning either disturbance are wanting. For occurrences farthest west, our vessel weather reports tell of the cyclone of July 31–August 1, 1925, near 15° N., 152° W., and the Segelhandbuch has two cyclones in the region earlier referred to as "No Man's Land," that occurred as far west as 161° W. and 174° W., respectively, the former in 1874, and the latter in 1858.

Monthly trends.—In most regions subject to tropical cyclones, there is a strong tendency for them to vary somewhat in locality of formation and direction of progression, according to the age of the season. This tendency does not seem to be as common among the cyclones of the Mexican west coast, except that with progress westward into the regions subject to the storms of the third and fourth groups, which comprise approximately a tenth of all the storms, the season appears to be retarded, not beginning until July or August.

SUMMATION

CYCLONES OF 1910–1928

A study of all the vessel weather reports received by the Weather Bureau from these waters for the period 1910 to 1928, inclusive, together with information furnished by the Mexican meteorological service, indicates that at least 95 cyclones have occured here during the past 19 years. In only two years of that period—1914 and 1916—has there been a seeming complete lack of revolving storms. The number of annual occurrences, arranged chronologically, is as follows:

1910, 3; 1911, 7; 1912, 4; 1913, 1; 1915, 4; 1917, 4; 1918, 3; 1919, 2; 1920, 3; 1921, 9; 1922, 7; 1923, 5; 1924, 3; 1925, 13; 1926, 8; 1927, 9; 1928, 10. The year 1925, with its record of 13 known cyclones, shows a season of maximum frequency and violence.

Thirty-two cyclones of the 95, or 34 per cent of the whole number, have been reported as sufficiently violent to cause full storm (force 11, Beaufort scale) to hurricane velocities within a restricted to a considerable area. Of these, by the year, 1 each occurred in 1913, 1918, 1919, 1923, and 1926; 2 each in 1911, 1912, 1917, and 1921; 4 each in 1922 and 1928; 5 in 1927; and 6 in 1925.

A distribution of the 95 cyclones for the 19-year period by months gives—

May, 1; June, 11; July, 14; August, 15; September, 34; October, 17; November, 2; December, 1.

The distribution of the known hurricanes for the period gives this result:

June, 1; July, 5; August, 6; September, 11; October, 8; November, 1.

CYCLONES OF THE DEUTSCHE SEEWARTE

A list of storms of these waters published by the Deutsche Seewarte (2) and covering the years 1832 to 1892, a period of 61 years, gives the following numbers by months:

June, 2; July, 8; August, 8; September, 11; October, 10; November, 5; December, 1—a total of 45.

Of these the following are recorded as having known wind forces of 11 to 12:

June, 1; July, 6; August, 2; September, 6; October, 9; November, 3; December, 1—a total of 28 out of the 45 cyclones enumerated, of which 62 per cent were thus of great violence, as against 34 per cent among the cyclones tabulated for the more recent period.

It is evident that the tabulation of known cyclones of very recent years is much more complete than for any previous period or years, owing to the fuller network of observations covering these waters, made possible by the opening of the canal, but more especially due to the rehabilitation of trade in these waters in 1921, following upon the depression caused by the World War.

The Segelhandbuch remarks upon the curious diminution in the numbers of hurricanes from July to August, according to the 61-year record. In the later record for 19 years, a practically equal number is assigned to each month, August having one the more. September in both cases sees the maximum in numbers, but the German record shows more cyclones of hurricane force in October than in September, while our record gives the greater number to September. Most November cyclones appear to be of considerable energy. In all cases the records are undoubtedly incomplete, very much so among the earlier years, and certainly in considerable measure, especially with reference to storm movements and violence among the later years. It seems well-nigh certain that many cyclones with reported maximum wind forces of 9 or 10 would have yielded higher velocities had the experiencing vessels been involved somewhat nearer to the respective centers.

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NOTE.—Further information as to the histories of individual storms, etc., may be found in an article written for the use of seamen by Willis Edwin Hurd, entitled "Tropical Storms of the Eastern North Pacific Ocean," appearing on various U. S. Hydrographic Office Pilot Charts, including that of the North Pacific Ocean, September, 1928, and of the South Atlantic Ocean, for the quarter, September, October, November, 1928.

DURATION OF RAINFALL AT BALTIMORE, MD.[1]

By ROSCOE NUNN

[Weather Bureau Office, Baltimore, Md.]

For many years the Weather Bureau has kept records of the duration of bright sunshine at the various stations, so that this feature of climate may be easily set forth in numerical data, or in charts, for the whole United States. We know the average number of hours the sun shines unobscured and the percentage of the possible amount received. These are interesting and important climatic data.

But information as to the number of hours rain falls is very scarce. We have beginnings and endings of precipitation for many years, and from these records it is quite possible to compile data showing how many hours per day, month, and year precipitation occurs. As yet, however, very little of this work has been done. It is hoped that what has been done with the sunshine

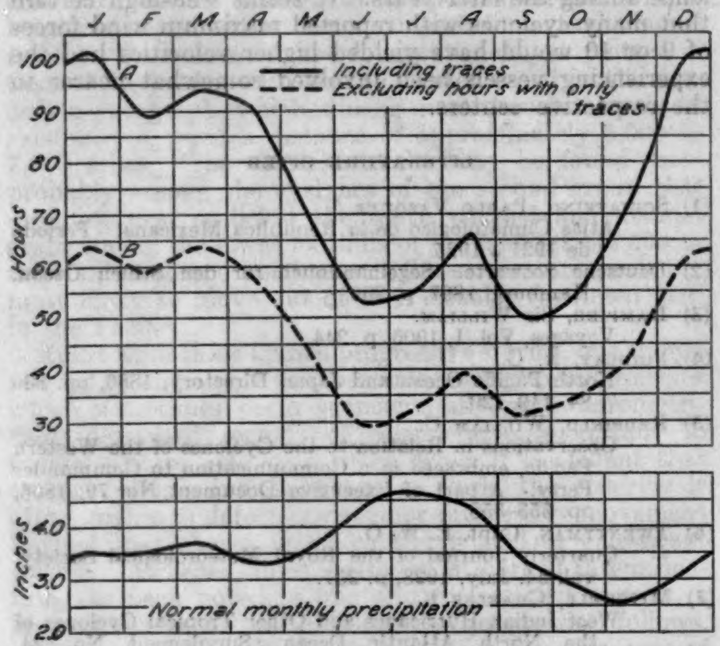

FIGURE 1.—Average total duration of precipitation, hours per month, Baltimore, Md., and normal monthly precipitation

records throughout the country may be done with the rainfall records.

Is it not just as interesting and important to know how much of the time rain falls as to know how much of the time the sun shines brightly? Is it not true that falling rain, or snow, or sleet, is of more concern to outdoor operations in general than is the presence or absence of bright sunshine? How does the number of rainfall hours at Baltimore compare with those at Boston, New York, New Orleans, Denver, Chicago, Cleveland, or any other station?

Fassig, in his "Climate of Baltimore," 1907, gives data on the duration of precipitation for each precipitation period or storm passage. For example, he found that the average duration per rain period, taking the year as a whole, is 8.2 hours. He counted the entire interval between the beginning and ending of precipitation of each storm, regardless of interruptions in the continuity of the fall. In this manner Fassig shows how long the average rainstorm or snowstorm lasts. Cox and Armington, in their book "Climate of Chicago," give similar data. These investigations—which are the only studies of the kind that have been published in the United States, so far as I know—and those described in the present paper are along somewhat similar lines, but are by no means the same.

At several Weather Bureau stations data on the frequency of precipitation have been compiled and published, but none of the works referred to covers the subject of the present paper, in which the purpose is to show just how much of the time precipitation occurs, on an average, per day, month, and year, and the distribution of precipitation hours through the day and the seasons.

To discover the facts, the hourly records of precipitation at Baltimore, Forms 1014, for a 10-year period, 1919–1927, were examined. The duration of precipitation for each hour was compiled and entered upon suitable forms. One form holds a month's record of precipitation duration data. These hourly precipitation duration data are exactly similar in arrangement to hourly sunshine data on Weather Brueau Forms 1014, daily local record. All beginnings and endings of precipitation were considered and all intervals between showers were eliminated. The totals for each day, in hours and tenths, were compiled. Then the monthly totals were computed.

In the first compilation all occurrences of precipitation, including periods with only traces, were counted and tabulated. Then a second examination of the records was made, in which all hours having only traces recorded were eliminated, and a total of the duration, excluding traces, was found. We thus have (1) the total duration of precipitation including periods with traces, and (2) the duration excluding periods with only traces and including only such precipitation as amounted to 0.01 inch or more within an hour. (Fig. 1.)

It is interesting to compare the two records. For example, it is seen that more than one-third of the duration of rainfall at Baltimore is for precipitation at the rate of only a trace an hour; for it is found that the average total precipitation hours for the year is 901 hours when traces are included and only 557 hours when traces are not counted.

It seems important to eliminate the traces—those periods of mere sprinkling or misting—when we consider the data in their economic bearing; for while sprinkling or misting often may be a drawback to outdoor operations, their effects are very slight as compared with those of a wetting rain. Therefore, the remainder of the discussion is based mostly upon compilations from which traces of rain were excluded.

From the hourly data for the 10-year period, 1918–1927, the total durations for each month and year were compiled, and from these the averages by months and the year. Excluding traces, the average precipitation hours at Baltimore, reduced to whole numbers, are as follows: January, 64 hours; February, 59; March, 63; April, 57; May, 44; June, 29; July, 32; August, 40; September, 31; October, 34; November, 42; December 60; for the year, 557.

The greatest monthly number of precipitation hours in the 10-year period was 114 hours, April, 1918; the least,

[1] Read before the American Meteorological Society meeting at New York, December, 1928.

1.8 hours, October, 1924. The greatest annual number of hours was 637, in 1920, and the least 502, in 1925.

It is thus seen that during the winter and early spring the average duration per month is nearly the same; that the duration decreases rapidly in the second half of April and in May, and reaches the lowest for the year in June; that it rises slightly in July, and rises considerably in August; that it falls in September to almost as low as in June; rises gradually in October, and rapidly in November and the first half of December.

Possibly, a more effective way of expressing the duration is found in giving the number of hours per day (on the average) that it rains in the different seasons, and we find that in January precipitation of some kind is occurring, on the average 2.1 hours per day; in February 2.1 hours per day; in March, 2.0; April, 1.9; May, 1.4; June, 1.0; July, 1.0; August, 1.3; September, 1.0; October, 1.1; November, 1.4; December, 2.0; for the year round, 1.5 hours per day.

Another way to put it is by the percentage method (Fig. 3.) In January, precipitation is occurring, on the average, 8.6 per cent of the time; in February, 8.7 per cent; March, 8.5; April, 8.0; May, 5.9; June, 4.1; July, 4.3; August, 5.3; September, 4.3; October, 4.6; November, 5.9; December, 8.1; for the year, 6.4.

Percentages afford the best comparison of one month with another, as the variations in the lengths of months are taken care of. In percentages, February is shown to be the rainiest period of the year, by a slight margin over January, which is the next rainiest; while June has a lower percentage of rainy hours than any other month, but with July and September almost as low. August has decidedly more rainy hours than July or September—a rather noticeable feature of the diagrams—which is probably due to tropical storms and other storms moving up the Atlantic coast, which sometimes cause lengthy periods of rain at Baltimore, and which, apparently, are more frequent in August than in July or September, this being the case, at least, in the 10-year records under consideration.

Another interesting investigation was the tabulations to show how the duration of precipitation is distributed through the 24 hours of the day, in the different months and seasons. For this purpose the averages for each hour of the day for the 10-year period were computed. (Table 1.) It was found that in the winter season the duration is greatest between about 5 a. m. and about 8 a. m., and least between about 5 p. m. and about 9 p. m. The highest actual average is for the hour 6 to 7 a. m., and the least actual average is for the hour 5 to 6 p. m. (Fig. 2.)

In the summer season the duration is greatest for the hour 8 to 9 p. m. and least for the hour 10 to 11 a. m. It was surprising to find that the greatest duration in summer was not in the middle of the afternoon or a little later, but comes as late at 8 to 9 p. m. However, the hours 4 to 6 p. m. do show the second greatest duration period and are distinctly marked as compared with the next preceding and next following hours. It may be that thunderstorms that occur late in the afternoon give a more persistent rainfall than those that occur in the warmest part of the day; but this I have not investigated.

The greatest average total duration of precipitation per month for any hour in the year is 3.4 hours (11 per cent), in January, between the hours of 5 a. m. and 6 a. m., and in December between the hours of 4 a. m. and 6 a. m. The least average total duration per month for any hour is 0.5 hour (1.6 per cent), for the 2-hour period, 10 a. m. to 12 noon, in July.

Winter and summer differ decidedly in precipitation duration characteristics, but spring and fall do not show very distinct characteristics in these data. Duration in early spring is very much like it is in winter, while in late spring it is very much like it is in early summer. In early fall it is much the same as in the summer, and in late fall it is pretty much the same as in winter.

On the other hand, there are two interesting similarities of winter and summer. (Fig. 2.) Both show an increase in precipitation duration during the hours 6 a. m. to about 8 a. m., and both show a decline in durations between the hours of about 8 a. m. and 10 a. m. and continue low until about noon, or a little later. The annual curve, of course, shows similar variations. It

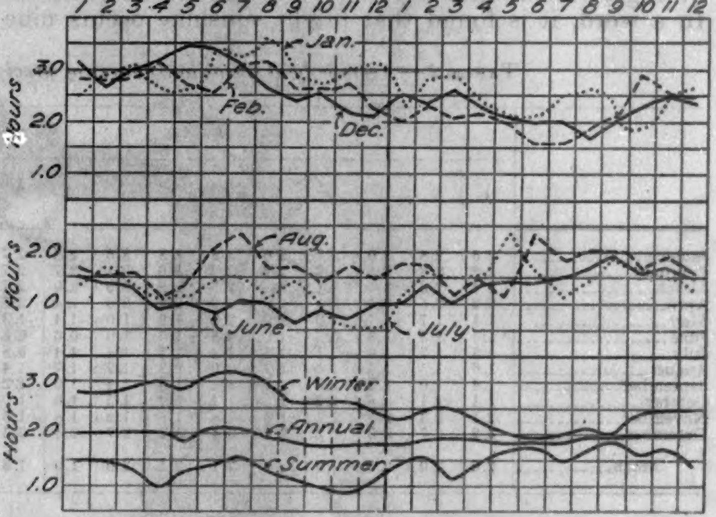

FIGURE 2.—Duration of precipitation; average total duration per month for each hour of the day, excluding traces, Baltimore, Md.

may therefore be said that rainfall duration is greatest between the hours of about 6 a. m. and about 8 a. m., and least between the hours of about 10 a. m. and about 12 noon, considering the year as a whole. These features may be explained by the normal temperature trend; that is, precipitation probably occurs more with falling temperature, or around the period of minimum temperature for the day, and occurs less with the rising temperature of the late forenoon.

The duration of precipitation in a climate such as we have in the eastern half of the United States is overestimated by most people. That was my opinion before making these studies. The facts brought out in this work convince me that the average person believes that rainy weather prevails much more of the time than the records indicate. And the average person probably underestimates the amount of sunshine, especially in the winter and spring seasons. I have therefore made diagrams to show comparisons between the number of rainy hours and the number of sunshiny hours at Baltimore. The diagram (fig. 3) shows the data in percentage of the time. The percentage method is preferable, because the proportions in the percentage diagram are accurate, while in the com-

parison by hours per day we must remember, and allow for, the fact that the sun works only half the day, on the

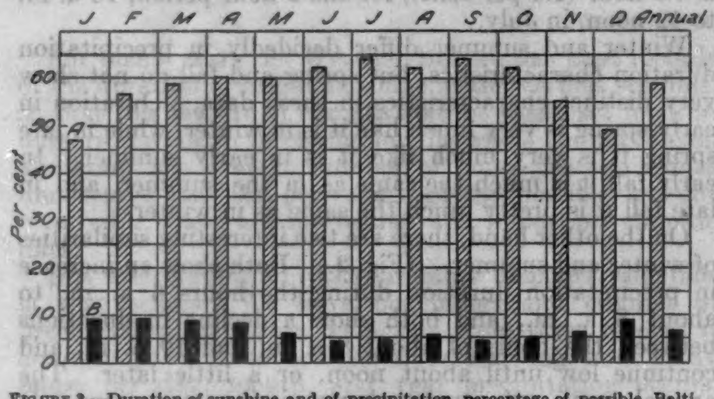

FIGURE 3.—Duration of sunshine and of precipitation, percentage of possible, Baltimore, Md. (A) Sunshine. (B) Precipitation

average, while rainfall is possible throughout the 24 hours. In a word, it is found that bright sunshine occurs nine times as much of the possible time as rainy weather occurs, taking the year round, at Baltimore; that is, the rainfall duration percentage of the possible for the year is 6.4 per cent, while the bright sunshine hours total 58.0 per cent of the possible.

TABLE 1.—*Total duration (hours) of precipitation, excluding hours with only traces, Baltimore, Md. (1919–1927)*

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1918	68.5	27.3	65.2	114.3	25.6	26.6	26.5	21.3	48.4	16.7	18.4	64.6	523.4
1919	65.8	57.7	70.2	38.9	66.8	22.5	57.6	35.2	14.4	67.2	65.5	70.7	632.5
1920	79.4	90.3	63.1	77.8	37.3	48.8	19.7	80.5	30.2	5.0	56.8	48.7	637.1
1921	46.5	53.0	48.4	48.9	73.3	13.9	29.3	29.6	14.2	23.9	82.3	47.9	511.2
1922	67.3	72.9	85.2	24.2	46.5	40.0	37.8	23.7	17.1	20.6	8.7	67.7	511.7
1923	67.7	59.0	71.1	60.2	25.0	17.7	29.5	33.5	32.3	30.3	41.5	76.6	544.4
1924	37.7	52.0	90.5	58.4	84.4	36.3	15.3	28.1	83.2	1.8	21.7	41.5	550.9
1925	93.6	26.7	51.6	50.8	15.6	18.6	35.2	29.4	11.5	76.2	46.3	46.4	501.9
1926	70.5	81.8	54.2	29.4	25.0	21.3	51.9	70.7	47.7	36.7	49.4	68.4	607.0
1927	42.4	69.2	29.5	71.1	42.5	47.8	20.5	45.0	11.6	67.0	32.7	72.5	551.8
Mean	63.9	59.0	62.9	57.4	44.2	29.4	32.3	39.7	31.1	34.5	42.3	60.5	557.2

TABLE 2.—*Average total duration (hours) of precipitation, excluding traces, Baltimore, Md. (1919–1927)*

	A. M.												P. M.											
	1	2	3	4	5	6	7	8	9	10	11	Noon	1	2	3	4	5	6	7	8	9	10	11	Midnight
January	2.5	2.8	3.0	2.7	2.6	3.4	3.3	3.6	2.8	2.7	3.0	3.1	2.3	2.7	2.7	2.4	2.1	2.1	2.6	2.6	2.0	1.9	2.5	2.7
February	2.8	2.8	2.8	3.2	2.7	2.6	3.0	3.1	2.7	2.7	2.7	2.3	2.0	2.3	2.1	2.1	1.9	1.6	1.6	1.9	2.1	2.9	2.5	2.5
March	2.4	2.8	3.1	3.1	2.8	2.8	2.8	2.9	3.0	2.7	2.5	2.9	3.0	2.5	2.6	2.6	1.9	2.5	2.2	2.4	2.5	2.7	2.0	2.7
April	2.2	2.5	2.4	2.1	1.9	1.9	2.4	2.6	2.4	2.5	2.5	1.8	1.8	2.3	2.5	2.6	2.4	2.2	2.3	2.8	2.8	2.8	2.9	2.9
May	1.4	1.7	1.7	2.2	2.0	2.2	1.8	1.6	1.4	1.3	1.4	1.7	1.5	1.3	2.0	1.9	2.1	2.0	2.4	2.5	1.6	2.3	2.2	2.1
June	1.5	1.3	1.3	0.8	1.0	0.8	1.0	1.0	0.6	0.8	0.7	1.0	1.0	1.4	1.0	1.3	1.4	1.4	1.5	1.7	2.0	1.6	1.7	1.5
July	1.3	1.7	1.3	1.1	1.1	1.4	1.5	1.1	1.4	0.8	0.5	0.5	1.1	1.6	1.5	1.5	2.4	1.7	1.2	1.4	1.9	1.7	1.5	1.2
August	1.6	1.5	1.5	1.1	1.7	2.0	2.3	1.7	1.7	1.4	1.6	1.5	1.7	1.7	1.1	1.4	1.2	2.3	1.9	2.0	2.0	1.6	1.8	1.5
September	1.4	1.0	1.2	1.0	1.2	1.3	1.5	1.4	1.0	1.2	1.2	1.0	1.1	1.2	1.2	1.2	1.2	1.3	1.5	1.9	1.5	1.4	1.5	1.3
October	1.1	1.1	0.6	1.2	1.2	1.2	1.4	1.5	1.6	1.9	1.6	2.2	2.0	2.1	1.7	1.4	1.4	1.5	1.5	1.3	1.4	1.4	1.0	1.2
November	2.1	2.3	2.1	2.1	1.6	1.8	1.5	1.2	1.8	1.5	1.6	1.7	2.1	1.6	1.9	2.2	1.8	1.7	1.7	1.7	1.6	1.7	1.5	1.6
December	3.2	2.7	3.0	3.2	3.4	3.4	3.2	2.7	2.4	2.5	2.2	2.1	2.5	2.3	2.6	2.3	2.1	2.0	2.0	1.7	2.0	2.3	2.5	2.4
Mean	2.0	2.0	2.0	2.0	1.9	2.1	2.1	2.0	1.9	1.8	1.8	1.8	1.8	1.9	1.9	1.9	1.8	1.9	1.9	2.0	2.0	2.0	2.0	2.0

A SIMPLE METHOD OF MEASURING THE DIFFUSED RADIATION OF THE SKY ACCORDING TO ZONES

By Prof. N. N. KALITIN

[Magnetic Meteorological Observatory Sloutzk (Pavlovsk) U. S. S. R.

The solar radiation diffused by the atmosphere is generally measured for the whole vaulted sky. Meanwhile the study of this radiation, not as total for the whole vault, but with regard to the several zones, presents a great interest, as much theoretical as practical.

I should like to give in this short note a description of a simple method applied by me for the above purpose. I made use of the well-known pyranometer of A. Ångström, a splendid instrument, giving, if shaded from the sun by a small screen, the intensity of solar radiation diffused by the atmosphere.

The complete installation is shown in Figure 1; the principle of its action is the following: The pyranometer is placed on the line of the axis of the cylinder B, the latter being subject ad libitum to being raised or lowered, and fixed in position by means of the screw H. If the upper rim of the cylinder be placed at the level of the plane within which are disposed the receiving plates of the pyranometer, the apparatus will be subjected to the effect of radiation from the whole vault of the sky. As the cylinder B is shifted higher and higher the vault is more and more covered, beginning with parts adjacent to the horizon, so that they will have no effect on the pyranometer.

The dimensions of the cylinder B being known, it is easy to compute beforehand the height at which the cylinder B must be placed so as to cover the vault to 10°, 20°, 30°, etc., from the horizon.

The installation constructed by me allows a covering of the sky by means of shifting the cylinder up to 60°. For a further screening of the sky a higher cylinder might be used; but as this is inconvenient I adopted the following proceeding: The cylinder B being adjusted at the height to screen the sky up to 60°, it is partly closed by the cover C, which has a round opening and screens the sky up to 70° from the horizon. If the cover D be substituted for the cover C, the sky is shaded up to 80°.

Thus the above adjustment permits us to measure the radiation of the whole vault as well as its several parts in the form of circular zones of any desired width. The cylinder B as well as the covers C and D have been lined with black velvet in order to avoid all possible reflection.

The ingenious arrangement of the receiving surfaces of A. Ångström's pyranometer eliminates any possibility

(To face p. 52)

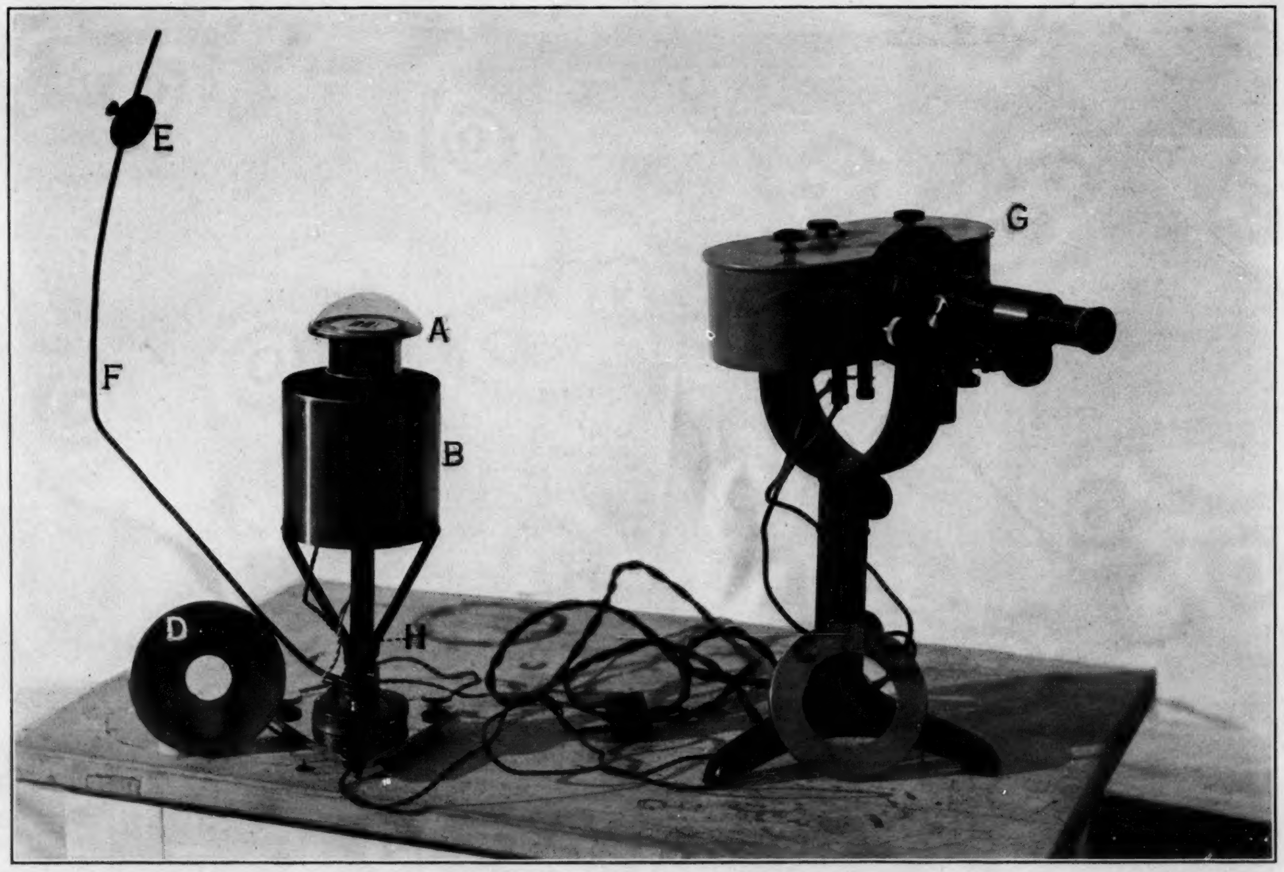

FIGURE 1.—Pyranometer A. Ångström, together with the loop galvanometer Zeis, adjusted for measurements of diffused radiation of the vaulted sky according to zones

of the effect of radiation from the outer side of the cylinder and the covers.

In the presence of solar radiation the pyranometer, as it is generally used, is shaded from direct rays of the sun by a small round screen (E), moving on a support (F).

For the measurement of radiation according to zones this pyranometer was applied by me as a relative apparatus together with the Schleifengalvanometer of C. Zeiss, G. With this galvanometer the whole process of measuring the radiation by zones 10° in width, the determination of radiation from the whole sky and also the verification of the position of the zero of the galvanometer before and after a series of observations, could be effected in three to four minutes. The advantage of the Zeiss galvanometer is that, by means of a turning over of the box 180°, its sensibility can be several times increased. For instance, my Ångström pyranometer No. 29 in connection with the Zeiss galvanometer in normal position gave for one division of the galvanometer the value of 0.0081 calorie; whereas with the same glavanometer with the box overturned, it gave 0.0025 calorie; which is especially valuable for observations during an expedition; and my experience enables me to heartily recommend the use of this galvanometer together with the Ångström pyranometer for expedition work.

As has been stated, measurement of radiation by zones can be effected for the whole sky in three to four minutes; the work has necessarily to be completed in a short interval of time, in order that the radiation of the vault shall not change materially during the measurement. In most cases the change is not material within so short a space of time, except in rare cases of an exceptionally rapid drift of clouds, when the radiation is apt to change considerably within a few minutes; then measurements of radiation according to zones ought not to be made.

I give here, as an example, four lines of measurements of radiation according to zones—two regarding a sky free of cloud and two for a sky covered with a dense sheet of cloud.

TABLE 1.—*Distribution of diffused radiation of the vaulted sky according to zones of a clear (entirely free of cloud) and an overcast sky*

Hours of observations	ϑ_+	h☉	A	0°–10°	10°–20°	20°–30°	30°–40°	40°–50°	50°–60°	60°–70°	70°–80°	80°–90°
Sky free of cloud:	*cal.*	°	*P. ct.*									
Sept. 22, 1928, 9h. 17m	0.080	26.6	100	5.3	12.2	16.2	17.7	16.5	13.7	9.3	5.6	3.1
Sept. 19, 1928, 10h. 23 m	.068	18.4	100	7.6	15.0	16.9	16.4	13.2	12.8	9.5	6.1	2.5
Cloudiness (10 SCu):												
Oct. 21, 1928, 12h. 55m	.084	18.2	100	3.1	5.6	10.8	15.0	16.5	16.2	18.3	10.2	4.2
Dec. 12, 1928, 11h. 33m	.048	7.1	100	4.2	5.3	10.6	13.2	12.7	15.9	18.5	13.8	5.8

Explanation to the table:

ϑ_+. Diffused radiation of the whole vault on a cm². of horizontal surface in 1 minute in gr. cal.

h☉ Altitude of the sun at the middle moment of observation.

A. Radiation of the whole vault (ϑ_+) taken for 100 per cent.

0°–10°, 10°–20°, etc., to 80°–90°. Radiation of respective zones of the vaulted sky; from the horizon to the height of 10° and so on up to 80° and from 80° height to the zenith—in per cent of the total radiation of the vault.

In Figure 2 the values of the table are given graphically and show that the distribution of radiation over the vault for a sky free of cloud differs from that regarding an overcast sky. In the first case the maximum falls on the zone 30°–40° and in the second on the zone 60°–70°. Besides, in the presence of a clear sky the zone adjacent to the horizon radiates more than the zone round the zenith, whereas the sky being overcast the case proves vice versa. After C. Abbot, H. Kimball, W. Dines, and C. Dorno's investigations, this is generally known, and I only want to show that by means of a very simple method here exposed it is possible to obtain the same results which are generally attained by more intricate procedures.

The exposed method allows an organization of systematic observation on the radiation of the several zones of the vaulted sky. The results obtained supply many valuable data regarding the effect of various meteorological elements and topographical features on the diffused radiation, as well as its dependence upon the height of the sun over the horizon.

Series of these observations may prove very valuable for health resorts and also for agricultural purposes (e. g., for the study of the effect on growing vegetation of the

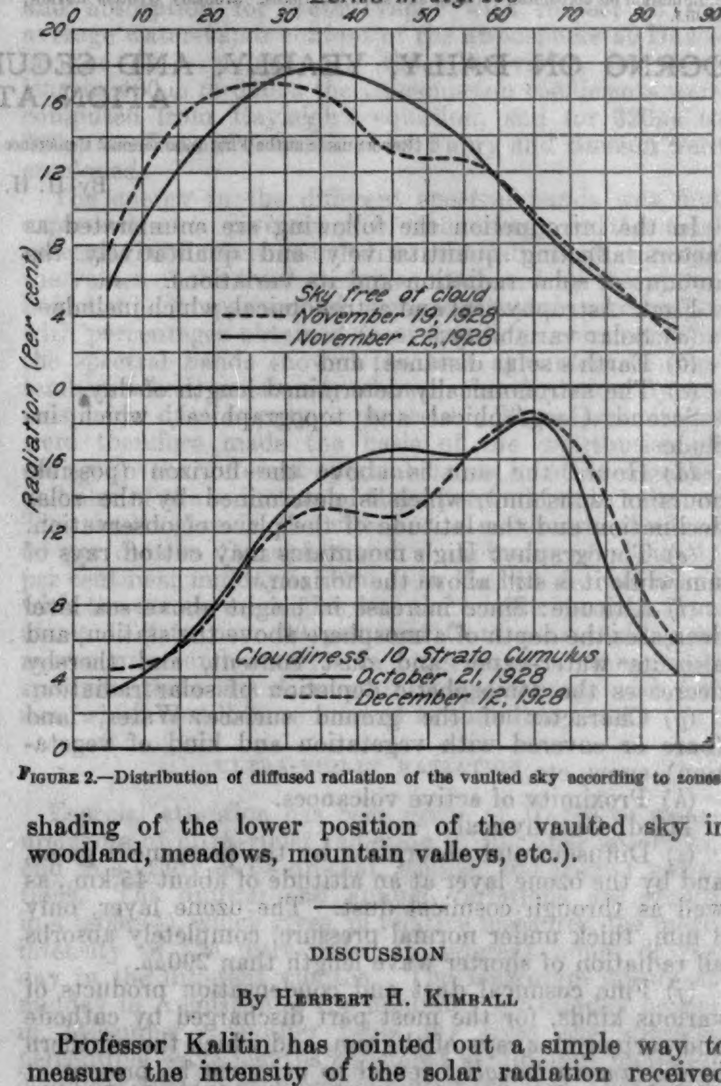

FIGURE 2.—Distribution of diffused radiation of the vaulted sky according to zones

shading of the lower position of the vaulted sky in woodland, meadows, mountain valleys, etc.).

DISCUSSION

By HERBERT H. KIMBALL

Professor Kalitin has pointed out a simple way to measure the intensity of the solar radiation received diffusely from the sky with apparatus easily obtainable. A method similar in principle has been employed by the Astrophysical Observatory at the Smithsonian Institution in measuring radiation from horizontal sky zones 30° in width; also from a ring 60° in diameter concentric with the sun, and from similar areas of equal dimensions and altitude located 60°, 120°, and 180°, respectively, from the sun.[1] The objection to these methods is that since the receiving surface of the pyrheliometric device employed has definite dimensions, different parts of it will be exposed to different sky zones. The smaller the dimensions of this receiving surface the less will be the

[1] Moore, A. F., and Abbot, L. H. 1920. The Brightness of the Sky. Smithsonian Miscellaneous Collections, vol 71, No. 4.

difference in the location of the zones measured. The resulting error will be inconsequential except when a boundary of a zone is in close proximity to the sun.

Equally as important as measurements of the relative intensity of diffuse radiation from the sun in horizontal sky zones are measurements of this intensity with reference to the sun's position, as was done by the Astrophysical Observatory, Smithsonian Institution,[1] and also photometrically by Dorno,[2] by Kimball and Hand,[3] and by others. In fact, a pyranometric measurement of the brightness of the sky in a restricted zone about the sun is an important factor in the *short method* of determining the solar constant now generally employed by the Smithsonian Institution.[4]

Our thanks are due to Professor Kalitin for calling attention to the importance of measurements that give the intensity of diffuse solar radiation received from different sky zones, which is dependent not alone upon the proximity to the sun but also upon the character of the ground surface over which the measurement is made (vegetation, sand, snow, water, etc.), and upon the water-vapor and dust content of the atmosphere.

[1] Moore, A. F., and Abbot, L. H. 1920. The Brightness of the Sky. Smithsonian Miscellaneous Collections, vol. 71, No. 4.

[2] Dorno, C. 1919. Himmelshelligkeit, Himmelspolarisation und Sonnenintensität in Davos, 1911 bis 1918. Veroff. des Preus. Met. Inst., No. 303, Abh. Band VI.

[3] Kimball, Herbert H., and Hand, Irving F. 1921: Sky-brightness and daylight illumination measurements. Monthly Weather Review, 49: 481. 1922: Daylight illumination on horizontal, vertical, and sloping surfaces. Monthly Weather Review, 50: 615.

[4] Abbot, C. G. 1919: Measurements of the solar constant of radiation at Calama, Chile. Monthly Weather Review, 47 :580. Abbot, C. G., and others. 1922: Use of the pyranometer in the measurement of the solar constant. Annals of the Astrophysica Observatory, 4: 79.

DORNO ON DAILY, YEARLY, AND SECULAR VARIATIONS OF THE SOLAR RADIATION AT DAVOS[1]

[Report made at the First International Conference on Light, Lausanne-Leysin, September 10-13, 1928]

By H. H. KIMBALL

In the introduction the following are enumerated as factors affecting quantitatively and qualitatively the amount of solar radiation and its variations.

First. Astrophysical and astronomical, which include—

(*a*) Solar variability;

(*b*) Earth's solar distance; and

(*c*) The astronomically determined length of day.

Second. Geographical and topographical, which include—

(*d*) Hours the sun is above the horizon (possible hours of sunshine), which is determined by the solar declination and the latitude of the place of observation.

(*e*) Topography: High mountains may cut off rays of sun while it is still above the horizon.

(*f*) Altitude: Since increase in height above sea level decreases the depth of atmosphere above the station, and also its water-vapor and dust content, and thereby decreases the atmospheric depletion of solar radiation.

(*g*) Character of the ground surface: Water, land (bare or covered with vegetation and kind of vegetation), snow, etc.

(*h*) Proximity of active volcanoes.

Third. Geophysical:

(*i*) Diffusion and absorption by the permanent gases, and by the ozone layer at an altitude of about 45 km., as well as through cosmical dust. The ozone layer, only 3 mm. thick under normal pressure, completely absorbs all radiation of shorter wave length than $290\mu\mu$.

(*j*) Fine cosmical dust and condensation products of various kinds, for the most part discharged by cathode and corpuscular rays of the sun, and which the northern lights (*aurora borealis*) reveal to us, must be present at great heights to a greater or less extent, depleting the solar rays to a variable degree.

Fourth. Meteorological—that is to say, the weather influences, extending to the upper cloud limit, or to about 10 to 12 km. of the 600 to 700 km. depth of the atmosphere:

(*k*) Principally determined by water in the atmosphere in gaseous (water vapor), liquid (water droplets), or solid (snow crystals) form. The invisible water vapor acts strongly to deplete the incoming radiation, partly through absorption of red and infra-red rays, partly through scattering, like other gas molecules inversely proportional to the fourth power of the wave length, or in connection with dust particles on which it collects, inversely as the square of the wave length.

On account of the great number and variety of factors influencing the spectral distribution and the intensity of solar radiation, the radiation climate of a place can not be accurately stated without radiation measurements and registration.

COMPILATION AND SCOPE OF EXISTING MATERIAL

With continuous measurements of the intensity of the total solar radiation covering 20 years, short gaps excepted, Davos has the longest record of any mountain observatory, and there is an older record at only a few places on the plains. The measurements were made partly with an Ångström compensation pyrheliometer and partly with secondary instruments controlled through comparison with the standard type. Continuous photographic records have been maintained since 1921 by means of the Davos pyrheliograph. The readings on the Ångström scale are reduced to the Smithsonian scale of 1913 by multiplying by 1.035.

Summaries of the measurements are given in both graphical and tabular form. Thus, in Table 1 are given hourly mean values (apparent time) of the intensity of solar radiation at normal incidence for each month of the year, expressed in gram calories per minute per square centimeter. The maximum midday mean is 1.495 in April, and the minimum, 1.354 in December, a range of 9.4 per cent. The maximum hourly mean is 1.516 at 1 p. m. in April and the minimum, 1.054 at 6 p. m. in June, a range of about 30 per cent. The low water-vapor content of the atmosphere in the spring as compared with the fall months, is the principal cause of the spring maximum of solar radiation intensity. Table 2, which gives annual means with the sun at altitude 30°, shows a maximum of 1.344 in 1921 and a minimum of 1.272 in 1925, with an annual average of 1.312. The corresponding annual average given by me for the years 1912–18 except that the monthly means were reduced to mean solar distance of the earth, is 1.35.[2]

[1] Tägliche, jährliche und säkulare Schwankungen der Sonnenstrahlung in Davos. (32 pp., 8 tables, 6 figs.) L'Expansion Scientifique Francaise. Paris, 1928.

[2] Kimball, Herbert H. 1927. Measurements of solar radiation intensity and determinations of its depletion by the atmosphere, with bibliography of pyrheliometric observations. Monthly Weather Review, 55: 161.

In the text reference is made to Lindholm's[3] determination of the depletion of solar radiation at Davos by atmospheric dust. It is interesting to note that for the years from 1914 to 1926, inclusive, the depletion by dust, including nuclei of condensation, averaged 4 per cent, that in 1921 it was 2.9 per cent, and in 1925 5.7 per cent, expressed in terms of the value of the solar constant as the unit.

This accounts for two-thirds of the difference between the maximum annual mean in 1921 and the minimum in 1925.

In the text attention is called to the atmospheric-optical disturbance following the eruption of Katmai Volcano in Alaska in June, 1912. In October of that month the deficiency in the total radiation was 18 per cent, which is the same as was obtained by me from seven widely scattered stations.[4] For August, 1912, I found the deficiency to be 22 per cent.

Figure 2 of Dorno's paper shows that the percentage loss by dust and condensation nuclei reaches a maximum of 6 per cent in May and a minimum of little more than 1 per cent from September to November. At least 2 per cent of the winter dust is attributable to local smoke.

Continuous records of the total solar radiation received on a horizontal surface from the sun and sky are obtained by means of a photographically recording pyrheliometer. The monthly and annual mean daily recorded totals are compared in Table 3 with corresponding means computed from the so-called *normal mean daily values*, or values obtained with cloudless skies, and the duration of sunshine as recorded by a Campbell-Stokes sunshine recorder. The computed daily totals are generally in excess of the recorded except for the months November, December, and January. The author points out that after a cold night the pedestal of the glass-sphere heliograph must become warm before the paper chart will begin to char. This may require an hour of sunshine with an intensity of 1.1 to 1.2 calories, while in summer intermittent sunshine is frequently shown as continuous. The maximum annual daily recorded total is 363 gr. cal. per cm^2 in 1927; the minimum, 312 in 1922. Here the effects of variations in annual cloudiness are apparent.

INTENSITY OF ISOLATED SPECTRAL BANDS

The spectrum was divided into bands as follows:

Ultra-red, 3,000$\mu\mu$ to 760$\mu\mu$.

Red, 760$\mu\mu$ to 630$\mu\mu$; mean optical center of gravity, 680$\mu\mu$.

Yellow, 630$\mu\mu$ to 560$\mu\mu$; mean optical center of gravity, 590$\mu\mu$.

Green-blue, 560$\mu\mu$ to 470$\mu\mu$; mean optical center of gravity, 518$\mu\mu$.

Violet, 470$\mu\mu$ to 400$\mu\mu$; mean optical center of gravity, 415$\mu\mu$.

Ultra-violet, 400$\mu\mu$ to 290$\mu\mu$; mean optical center of gravity, 315$\mu\mu$.

The different bands required different methods of measurement, as follows:

Ultra-red; heat measurements.

Red, yellow, green, photometric measurements.

Blue and violet, photoelectric measurements (potassium cell).

Ultra-violet, photoelectric measurements (cadmium cell).

Absorption screens were employed to isolate the different spectral bands except in the ultra-violet, where the cells employed determine the spectral limits included in the measurements.

The extraterrestrial solar spectrum energy curve derived from observations by Abbot and Fowle[5] on Mount Wilson was employed except in the ultra-violet, where the curve was computed by Planck's equation for radiation from a black body at a temperature of 6,000° absolute.

Solar spectrum energy curves for different hours on the 15th of December, March, June, and September, respectively, were computed from the coefficient of scattering for dry air, and the coefficients of scattering and absorption for water vapor with respect to the average water-vapor content of the atmosphere at Davos on the dates named. In the ultra-violet, for wave lengths 400$\mu\mu$ to 320$\mu\mu$ the transmission coefficients were computed from Rayleigh's equation, and for 320$\mu\mu$ to 290$\mu\mu$ coefficients determined by Fabry and Buisson were employed.

The energy in the different spectral bands was first expressed as a percentage of the energy in the total spectrum and then reduced to absolute units through the values of the total energy as measured by the pyrheliometer. Comparison of these computed percentages with percentages obtained from actual measurements in the spectral bands showed the best agreement in September, when, as already shown, the depletion by atmospheric dust is only 1 per cent. These percentages were therefore made the basis of the distribution of energy in the different spectral bands in other months, and also of the reduction of these percentages to calories. The results give in the ultra-red a maximum of about 50 per cent in December and a minimum of about 41 per cent near midday in June. In the red the variations with the season are slight, but there is an increase from about 17.6 to over 20 per cent from near midday to near sunrise and sunset. In other parts of the visible spectrum there is a decrease in the percentage with low sun, which is still more marked in the ultra-violet.

ULTRA-VIOLET RADIATION

Especial attention has been given at Davos to measurements of ultra-violet radiation in the solar spectrum, and to a study of its diurnal, annual, and secular variations. The diurnal and annual variations are shown in a table (4), which gives, in relative measures, the mean intensity of the ultra-violet at different hours of the day in the different months. The maximum occurs at midday in August, and the minimum for midday occurs in December. Another table (6) gives the shortest perceptible wave lengths registered at different hours on cloudless days for each month during the year, December, 1908–November, 1909.[6] The shortest perceptible wave lengths registered at any time is 293.9$\mu\mu$ between noon and 1 p. m. in April. The shortest measured in December is 306.2$\mu\mu$, between the same hours. Between 5 a. m. and 6 a. m. in August the shortest wave length measured is 320.2$\mu\mu$. It is apparent that the energy between wave lengths 302 and 298$\mu\mu$, which is most effective in biological reactions, is found only with high sun.

[3] Lindholm, F. 1927. Über die Staubtrübung der Atmosphäre 1909 bis 1926, Beiträge zur Physik, 18: 127.

[4] Kimball, Herbert H. 1925. Variation in total solar radiation intensities measured at the surface of the earth. Monthly Weather Review, 53: 527.

[5] Later and more accurate data on the extraterrestrial solar energy curve is given by these authors in Smithsonian Miscellaneous Collections, vol. 74, No. 7.

[6] This may be compared with monthly means for the same period, and including records obtained on days when cirrus clouds were present, given in *Strahlentherapie*, 1924, 18:734.

A systematic variation is noted in the absolute values of ultra-violet radiation from year to year. From a maximum in 1915–16 the value decreased to a minimum in about 1922, and again reached a maximum in 1926. The amplitude of the monthly variations (difference between the maximum and the minimum values, expressed as a percentage of the mean value for the period 1915–1927) varied from 34 per cent in April to 52.3 per cent in July.

Since the sun spot maximum occurred in 1917, and presumably also in 1928, with the minimum in 1923, it appears to the author as has been claimed by him since 1917, that the emitted solar radiation is the strongest at the beginning of solar activity, instead of at its maximum, and, analogously, the same is true for the minimum.

Meteorologists are greatly indebted to Professor Dorno for the excellent summary of his observational work on solar radiation at Davos. Unfortunately it is not possible in a brief review to bring out all the important information it contains.

My thanks are due to Mr. W. W. Reed for assistance in interpreting some passages in the German text.

SUMMARY OF THE PRESENT STATE OF OUR KNOWLEDGE OF THE DISTRIBUTION OF OZONE IN THE UPPER ATMOSPHERE

By G. M. B. DOBSON

[Boars Hill, Oxford, England, February 18, 1929]

By the very kind cooperation of several meteorologists we have been able to make a study of the distribution of ozone under different meteorological conditions by observations at six stations in northwest Europe during four months in 1926 and eight months in 1927. A full account of this investigation is published in the Proceedings, Royal Society of London,[1] together with the results of a year's observations at Montezuma, Chile, and the first values from a new series of observations begun at California,

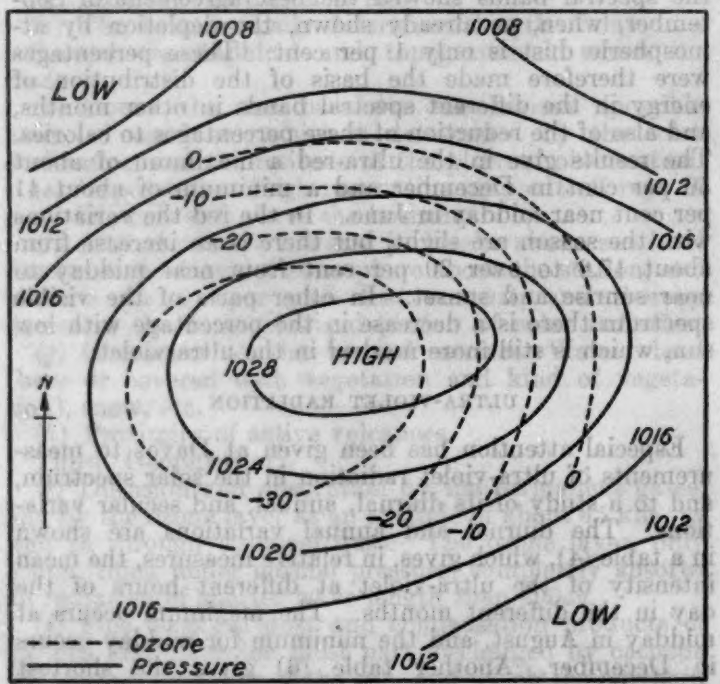

FIGURE 1.—Variation of ozone in connection with an anticyclone

Egypt, south India, and New Zealand. The most important results of these observations, together with those of other workers, are summarized below.

I. The variations of the amount of ozone with different meteorological conditions, with different times of year and with different latitudes is best seen by means of Figures 1, 2,[2] and 3.[3] Since the number of observations is small the diagrams must not be trusted for small details. (The average amount of ozone is equivalent to a layer of the pure gas some 3 mm. thick at 0° C. and 760 mm. Hg. The unit used in the diagrams is 0.01 mm. of the pure gas.)

II. The amount of ozone is more closely related to the conditions in the upper air than to those at the surface.

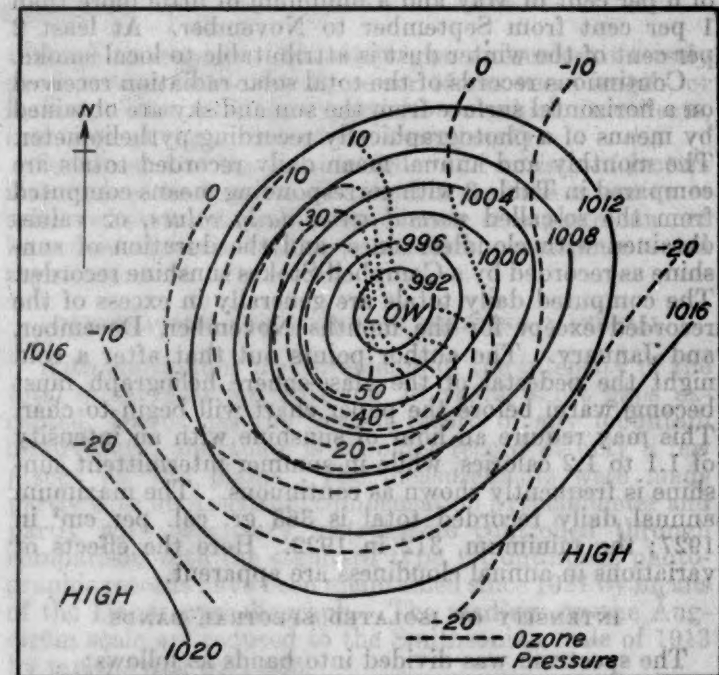

FIGURE 2.—Variation of ozone in connection with a cyclone

The connection with the conditions at 10 to 15 kms. is very close. There are not enough free-air observations to

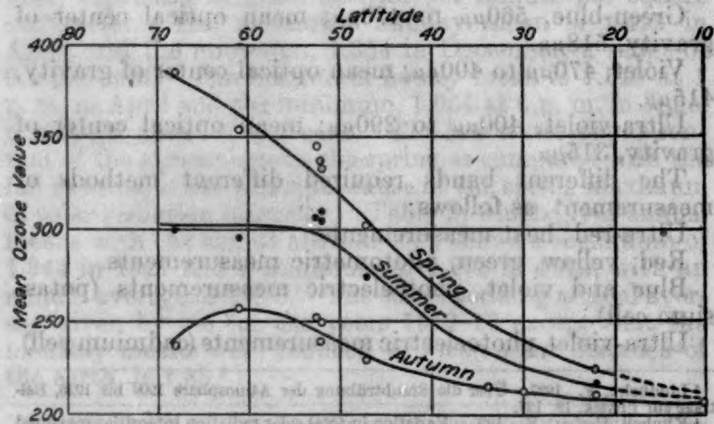

FIGURE 3.—Variation of ozone with season and latitude

show whether this connection is closer or less close at still greater heights. The amount of ozone is correlated:

[1] Dobson, Harrison & Lawrence. Roy. Soc. Proc. A, vol. 122, p. 456 (1929).
[2] Reproduced by permission of the Council of the Royal Society from the Proceedings.
[3] Reproduced by permission of Geh. Prof. Hergesell from Beit. Phys. d. f. Atmos.

a. Positively to the pressure at the base of the stratosphere.
b. Negatively with the height of the base of the stratosphere.
c. Negatively with the pressure at 10 kms.
d. Negatively with the temperature of the troposphere.
e. Negatively with the density of the air at 15 kms. (as shown by Dr. Duckert).
f. Positively (but less closely than the above) with the temperature of the stratosphere.

The correlation coefficient in the first five cases is about 0.7 to 0.8, and it is difficult to say in which case the connection is the closest.

g. The amount of ozone is also closely related to the the origin of the air currents in the upper part of the troposphere. Polar currents are associated with much ozone and equatorial currents with little ozone.

III. The average height of the ozone layer in temperate regions is about 45 to 50 kms. This is shown by the observations of M. M. Cabannes and Dufay, and of M. M. Lambert, Déjardin, and Chalonge in France, and by those of Professor McLennan and his associates in Canada. These observations were made shortly before sunset or after sunrise. Very numerous observations by Doctor Götz in Switzerland, at times when the sun was higher than in the French or Canadian observations, show similar heights. These latter observations also show that there is no large variation in the height of the ozone either with time of year or with the amount of ozone. If anything the height seems to be greater in spring and in cyclonic conditions when the amount of ozone is large.

The temperature of the upper air, deduced from the observations of meteors, indicates that the temperature above 55 kms. is relatively high compared to that below. These observations do not indicate at what height the temperature begins to rise with increasing height.

Again, the observations of sound waves at a great distance from their source indicate that the temperature begins to rise at a height of about 35 kms. and reaches a temperature equal to that at the ground at a height of about 40 to 45 kms., while it continues to rise up to heights of some 60 kms. or more.

The high temperature at these great heights can only be explained by the presence of ozone which absorbs some 6 to 7 per cent of the total incoming solar energy, while it can radiate but little energy. The calculations of Gowan of the temperature at different heights, taking account of the presence of ozone, is in reasonably good agreement with the results from meteors and sound waves, thus confirming the existence of ozone at 40 kms. and more.

There is little, if any, ozone in the lower air as shown by the experiments of Lord Rayleigh and Dr. Götz.

IV. The changes in the amount of ozone in cyclones and anticyclones might be explained by assuming that the great polar and equatorial air currents associated with these pressure systems extend up to heights of 50 kms., or more, and carry with them the amount of ozone which was present at the place of their origin. This simple explanation cannot, however, be true since the following arguments show that these polar and equatorial currents do not extend above about 20 kms.

a. The low temperature of the stratosphere near the equator and its high temperature near the Poles seems to continue up to heights of at least 20 kms. and probably more.
b. The temperature at 20 kms. is practically the same over cyclones as over anticyclones, and does not vary much from the normal temperature of the stratosphere for the latitude.
c. The above results indicate that the polar and equatorial currents associated with cyclones and anticyclones do not extend up to 20 kms., since otherwise the temperature at this height would vary in the same manner as that at 12 to 16 kms.
d. Further, direct observations of balloons at great heights show that the wind velocity, and therefore the pressure gradient, falls off with increasing height in the stratosphere and is very small at 18 to 20 kms. This again indicates that the effect of the cyclone does not extend above 20 kms.

V. The ozone is destroyed rather than formed by solar radiation. This is shown by the following observations:

a. The amount of ozone is small at places in the Tropics.
b. The amount of ozone at the Poles reaches a maximum in the spring at the end of the long winter night, and a minimum in autumn after the long summer day, the amount of ozone falling very rapidly about May when the total solar energy received per day is increasing fast.

The decomposition of ozone by sunlight seems to be slow as there is no appreciable difference between the average amount measured soon after sunrise and that measured shortly before sunset.

VI. The following two important questions can not, unfortunately, be answered at present, and further progress will probably depend on their solution:

a. How is the atmospheric ozone formed?

The only action which seems likely is one connected with the aurora. The visible aurora seldom comes lower than 95 kms. so that this itself can not be the immediate cause as ozone formed at this height would sink very slowly. Again, if formed only in high latitudes and destroyed by sunlight one would expect that air which had been circulating for a long time in equatorial regions would have very little ozone, whereas we find that it has a fairly uniform amount, equal to about half that found at the Poles in spring. It is possible that the amount of ozone which would be in equilibrium under the action of all the wave lengths of sunlight is about that found in tropical regions so that sunlight tends to reduce the amount of ozone to this level but not below it.

b. What causes the connection between the amount of ozone and the conditions at about 10 kms.?

Since the action of polar and equatorial currents can not affect the amount of ozone (see IV), it is difficult to suggest any action by which the conditions in the upper troposphere or lower stratosphere could affect this amount without reducing the average height of the layer when there is much ozone. Such a reduction of height has been shown not to take place. It is equally unlikely that changes in the amount of ozone could produce the pressure differences below, since the only appreciable action would seem to be to change the amount of solar energy absorbed, and this change is small. The proportion of the total solar energy absorbed by the ozone layer is about 5.6 per cent when there is little ozone and about 6.7 per cent when there is much ozone. Further the connection between the amount of ozone and the pressure at about 10 kms. is much closer that that between the ozone and the temperature above 10 kms.

FOWLE ON ATMOSPHERIC OZONE: ITS RELATION TO SOME SOLAR AND TERRESTRIAL PHENOMENA [1]

By HERBERT H. KIMBALL

This paper gives the results of a research for which a preliminary report was made a year ago, and published in the Journal of Terrestrial Magnetism and Atmospheric Electricity, 33: 151, 1928. For his observational data he used the solar spectro-bolograms obtained by the Astrophysical Observatory, Smithsonian Institution, at its observing stations at Harqua Hala, Ariz., Montezuma, Chile, Table Mountain, Calif., and Mount Brukkaros, Africa. Bolograms for about 1,000 days were utilized. On many days as many as six bolograms were obtained at an observing station, a number quite sufficient to determine atmospheric transparency at any desired wave length within the limits at which measurements were made.

The region of the spectrum selected for the study was that covered by the Chappuis band, in the yellow and red, between 0.450μ and 0.650μ. While not visible to the eye even under the most favorable circumstances, Fowle concludes that for the amount of ozone present in the atmosphere this band is a more sensitive indicator of changes in atmospheric ozone than the long-wave portion of the Hartley band, in the ultra-violet (wave-length under 0.310μ).

Fowle's determinations and conclusions differ from those given by Dobson in several respects. We quote his summary in full as follows:

SUMMARY

The amount of energy absorbed from the incoming solar radiation by the yellow ozone band has been used to measure the variations in the amount of atmospheric ozone during the years from 1921 to 1928. These observations have been made in both the Northern and the Southern Hemispheres.

The resulting values show a distinct yearly march in both hemispheres. In the Northern Hemisphere the maxima of this march occur between April and May, the minima between August and November; in the Southern Hemisphere the maxima occur between August and September, the minima between April and May. In other words in both hemispheres the maxima occur in the spring, the minima in the autumn.

In the Northern Hemisphere a marked relationship exists between the ozone and the Wolfer sun-spot numbers. The range in the monthly mean values for the ozone numbers is great and between 20×10^{-4} and 100×10^{-4} calories absorbed per cm.[2] per minute from the incoming solar energy.

In the Southern Hemisphere no such marked relationship is noted, although one may be masked by the small range and corresponding inaccuracy in the values. The range is only from 20×10^{-4} to 50×10^{-4} calories.

It is suggested—and such a suggestion is strengthened by magnetic data—that we are dealing with two layers of ozone. The first is due to ultra-violet light coming from the sun and hence existing over all the stations. The second is assumed to be due to positively electrified particles emitted from definitely disturbed areas of the sun. This second effect reasonably shows a strong correlation with the Wolfer sun-spot numbers. Probably because these positive particles are deflected towards the earth's north pole this layer of ozone is found over the Northern Hemisphere stations only. At sun-spot minimum it is negligible so far as the present measurements indicate.

All the results of the present paper are based on monthly and yearly means. A consideration of the daily values would be another story. The plot published in the preliminary paper was based on daily values for only two years at Table Mountain. The short study then made of the daily values would indicate that what may be said of the connection between many magnetic values and solar disturbances may be said of ozone; that although with monthly and yearly averages, solar spottedness, for example, goes hand in hand with the amount of ozone, yet a day of many spots may pass with no increase of ozone and vice versa.

Our thanks are due to both Dobson and Fowle for their careful work in this difficult field of research. When we appreciate the difficulties attending the measurements they are making it is not surprising that their results and conclusions are not in complete accord. Both, however, have contributed materially toward the final solution of a question of great interest and importance to meteorologists.

[1] Fowle, Frederick E. Smith. Misc. Coll., 81: No. 11. 1929.

SEVERE WINTER IN EUROPE, 1928-29

By CHARLES F. BROOKS and N. H. BANGS

[Clark University, Worcester, Mass.]

The stormy conditions, so prevalent during November (see Bulletin Amer. Met'l Soc. for December, 1928, pp. 206-207) over northwestern Europe, continued for the most part during December, culminating in a severe storm in the last week of the month, centered over the eastern North Atlantic and Scandinavia. Westerly gales caused by this disturbance brought high tides and floods along the Belgian lowlands, inundating districts that were just emerging from the floods of the previous month. Germany experienced the most severe fog in recent years, and Russia [U. S. S. R.] reported serious floods along the Neva from the melting snows. No particularly low temperatures were reported.

Conditions changed decidedly with the advent of 1929. By January 4 pressure had increased to 1040 mb. (30.71 in.) over central Europe, and an area of low pressure remained stationary over the Mediterranean.[1] This pressure distribution brought cold northerly winds to France and heavy falls of snow even to the Mediterranean coast, Marseilles reporting a fall of 6 inches. In Italy heavy rains caused floods. From then until the middle of the month pressure tended to remain high over Europe. At times there was a curious northwest-southeast trend to the area of high pressure, with one center in the vicinity of Iceland and the other over Poland. The tendency for the pressure to remain high over Iceland was one of the remarkable characteristics of January, 1929, for only once before, in 1846, has pressure averaged as high over Iceland as in the month under discussion.[2] About the 13th of the month a very severe storm, center 980 mb. (28.94 in.), appeared over Russia, and westerly gales and warmer weather prevailed. Toward the end of the month, while a low-pressure area of extraordinary depth (948 mb., under 28.00 in.) and extent developed and remained over the northwestern Atlantic (see Bulletin Amer. Met'l Soc. for January, 1929, pp. 52-53), pressure began to increase to the north and northeast of Europe, one HIGH, 1045 mb., (30.86 in.) being centered in the vicinity of Spitzbergen, and the other, 1056 mb. (31.18 in.) over eastern Russia.

[1] Information from daily "Chart of Weather in the Northern Hemisphere." Air Ministry (British) Meteorological Office, London.

[2] Cf. Dr. C. E. P. Brooks, in the Meteorological Magazine for February, 1929.

By the 29th the Russia HIGH, laying down a deep snow-blanket as it came, had advanced southwestward and a LOW developed over the eastern Mediterranean. From then on this type of pressure distribution of HIGH in central or north Europe, and LOW over the Mediterranean maintained itself, with a snow-cold-more snow-continued-cold flywheel, without a real break until February 22.[3] The pressure at the center of the HIGH rarely fell below 1035 mb. (30.56 in.) and was constantly replenished by a further influx of cold air from Siberia. The cold air was not deep enough to affect the high Alps, where sunny, comfortable weather prevailed.

The results of such a distribution have filled the pages of the newspapers with countless stories of record low temperatures, tremendous snowfalls, and unprecedented hardship and suffering. The lowest temperatures occurred during the second week of February when the pressure was the highest. Some of the temperatures quoted in the press were: −67° F. at Ivanov-Voznesensk, northeast of Moscow (the previous low for this district being about −50° F.); −40° F. near Vilna in Poland; −31° F. to −49° F. in Silesia; −24° F. at Belgrade; −21° F. at Vienna, −18° F. at Belfort, −15° F. in Berlin. This is the lowest official temperature ever recorded in Berlin. The official records were mild compared with the accounts of hardship, suffering, and death. From the Baltic, where over 40 ships with 1,400 passengers were frozen fast in the ice, to the bread lines of Vienna, and to the still more horrible tales of the wolf-infested villages of the Balkans, was spread a long train of human misery.

The heaviest snowfall occurred apparently in southeastern Europe along the northern border of the Mediterranean LOW, where the warm, moisture-laden air was forced to rise above the cold surface air from the northern HIGH. Three feet of snow fell on Constantinople during the week ending February 9; and the Simplon express was buried for 11 days in a snowdrift in the Balkans. And now come the floods.

Swedish meteorologists, said a news cable, ascribed the severely cold weather to an unusually warm Gulf Stream, presumably the Gulf Stream drift in the Norwegian Sea, which was said to be 5° C. above normal. This explanation harked back doubtless to Dr. J. W. Sandström's paper on the influence of the Gulf Stream on the winter temperature in Europe, published in the Meteorologische Zeitschrift two years ago.[4]

In this paper, Doctor Sandström shows, inter alia, how strong southwesterly winds and large plus departures of temperature in the Lofoten Islands of Northwest Norway, in winter attend cold weather over all but the extreme northwest of Europe, as was the case this year, and he ascribes to the temperature of the Gulf Stream drift near by the primary rôle in this situation. He offers no reasons why the Gulf Stream drift should be considered primary, however, and so it seems difficult to indorse this explanation which appeals so strongly to the imagination and which suggests a Gulf Stream basis for long-range forecasts of European winter temperatures.

How these southwest winds and a warm Gulf Stream make Europe cold is ingeniously explained as a result of the deflective effect of the earth's rotation. The strong southwesterly wind along the coast of Norway, between the warm air at sea and the cold over the continent, is the outflowing wind, from the accumulation of air over the continent, that has been deflected to the right. The southwest wind by virtue of this deflection now exerts an eastward pressure on the cold air over the continent and holds it in check causing it to pile up thereby increasing and continuing the cold weather of the interior. This explanation, based on Doctor Sandström's observations in northern Sweden, showed also why such heavy snows occurred while the cold air was held in check. The western front of the cold air mass is so steep and rises so high that the oceanic winds flowing up and over are cooled rapidly and at low temperatures, therefore, depositing abundant snow. The mechanics of the winter of 1923–24, which was very cold and snowy in Sweden and elsewhere in Europe, were discussed in some detail as an example.

While there can be no question that the action just described attends cold weather in Europe, it is difficult to ascribe its origin simply to the warm, or Gulf Stream, element. The accumulation of cold air over the continent is equally and coincidently involved. This massing of the cold air, it is true, is derived from the expanded air over the warm oceanic waters, perhaps chiefly the Gulf Stream drift of the North Atlantic. However, the way the pressure in the extreme northeastern Atlantic and over North Europe rose as the deep LOW formed in the northwestern Atlantic late in January, 1929, is strongly suggestive that the air leaving the northwestern Atlantic as the LOW formed accumulated in large measure far to the northeast and was essentially responsible for the subsequent southward and southwestward spread of cold air that initiated the Euopean cold period. Lieut. Commander E. H. Smith's observation of a 5° C. plus departure of sea temperature over a large area in the northwestern Atlantic in the early fall[5] may have favored some of the low pressure in this region later. Thus it does not appear that the high ocean temperatures in the northeastern Atlantic were more than a minor cause of this cold spell. In any event, it would be hard to explain why, if such ocean temperatures, which do not change rapidly, were primarily responsible, the cold weather should have come on rather suddenly and not been more the rule earlier in the winter. Furthermore, the lowness of pressure over the Mediterranean and, late in winter, the advance of a great HIGH from Northeast Greenland, and perhaps from Alaska, to a central position over Europe March 1 and 2, indicate other important contributing factors to the cold winter.

The periodic recurrence of cold winters at 100-year intervals, just nine times the sunspot period, was noted by H. Memery, of Bordeaux, and the likelihood of an extremely cold winter at this time and of a moderately cold one next winter was indicated at this time of waning sunspots.[6] The simultaneous occurrence of a cold winter in the interior and west of North America in positions corresponding to those of Europe may be significant of a general control such as solar heat rather than of a more local one of Atlantic Ocean temperatures, though the latter may be a feature secondary to the effect of the high solar activity of the past summer.

The temperatures that occurred in Europe were not extraordinarily low considering the latitude. Weather equally cold and persistent, but less severe on the people

[3] Weather maps for Feb. 11 and 13, isotherms for Feb. 13, and temperature change maps for Feb. 10, 11 and 13, 1929, over Europe, with discussion by F. Honoré, are published in L'Illustration, Paris, Mar. 2, 1929, p. 208 and 209.

[4] J. W. Sandström, Uber den Einfluss des Golfstromes auf die Wintertemperatur in Europa. *Met. Zeits.*, Nov., 1926, vol. 43, pp. 401–411, 47 figs. (Summarized by A. Walters in Met'l Mag., Apr., 1928, vol. 63, pp. 61–63, fig.)

[5] Science Service news reports of the *Marion* expedition, July to September, 1928.

[6] Cf. note by C. F. B. in MONTHLY WEATHER REVIEW October, 1928, 56: 417.

because it was less extraordinary, occurred in corresponding latitudes in the interior of North America this winter. The oceanic effect with the prevailing westerly winds is so strong in Europe in a normal winter that a change to continental conditions with easterly winds is striking. The usual position of the axis of high pressure in winter in Europe is only a little to the north of the Mediterranean, and in a latitude where severe cold does not usually develop. This winter, however, the axis of high pressure was about 10 degrees of latitude farther north, bringing extreme continental weather over central and northern Europe in consequence.

THE STEAMSHIP "METEOR" SURVEY OF THE TROPICAL AND SOUTH ATLANTIC OCEAN

Preliminary Report [1]

SUMMARY OF METEOROLOGICAL PORTION [2]

By CHARLES F. BROOKS

The comprehensive 2-year oceanographic and meteorological expedition of the German gunboat *Meteor* [3] to the little-known tropical and South Atlantic Ocean grew out of the late Dr. Alfred Merz's desire to test and develop his new theory of oceanic circulation. Doctor Merz's plans were so well laid that, in spite of his most unfortunate and untimely death early in the expedition, the other scientists, under the leadership of Capt. F. Spiess, were able to complete the survey as projected. Descriptions of equipment, methods, and preliminary results, and the narrative account published during the progress of the work early provided much valuable information, that was helpful, for example, for the program of the *Carnegie*, which set sail on its 3-year cruise less than a year after the *Meteor* returned. This review will take up, first, a few of the outstanding features brought out in the narrative, then, the special investigations of evaporation, meteorology of the surface layer, and aerology.

NARRATIVE OF THE EXPEDITION

After a month's trial trip followed by two months in port making changes, the expedition sailed from Wilhelmshavn in April, 1925, and enjoyed an introductory profile across the zones en route to Buenos Aires. The first 5 of the 14 crossings of the Atlantic (see fig. 1) were between the subtropical high-pressure belt and the south polar region, a stretch of ocean that gave the expedition a full measure of its proverbial storminess in winter and spring. The summer weather, while the expedition was in the highest latitudes, was exceptionally favorable, however. Once the ship found itself in the rather quiet center of a fairly strong cyclone for 10 hours, and the observers succeeded in making a kite flight. In latitudes about 60° and higher, beyond the poleward boundary of the westerlies, the flights showed pronounced surface inversions of temperature.

The SE. trade was found to be a cold-air body, that with a sharp top rises from a shallow sheet at the African coast and steeply falls off at a varying distance from the American coast. Apparently this western limit is in a standing wavelike motion, which for the South American coast area has the same significance as the polar front for the west-wind zone. On Profile VII, latitude 22° mostly, the clouds were regular St. Cu. at 1,400 meters and above these, at the height of the temperature inversion, many kite flights showed a 6° to 16° C. rise in air temperature.

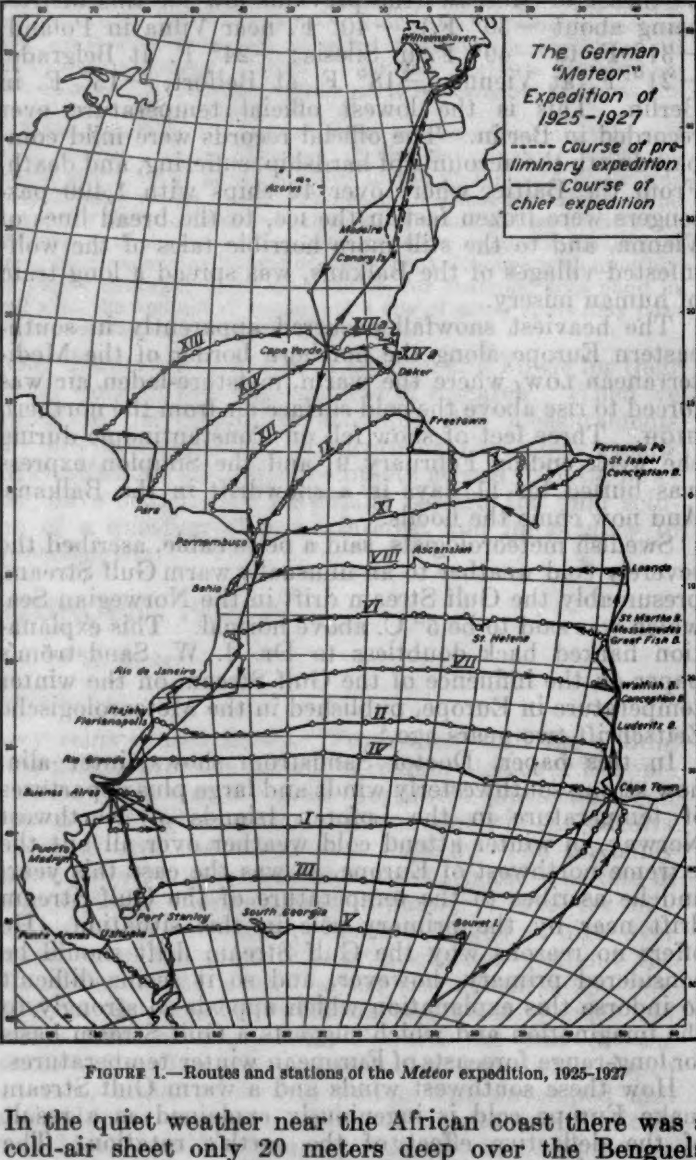

FIGURE 1.—Routes and stations of the *Meteor* expedition, 1925-1927

In the quiet weather near the African coast there was a cold-air sheet only 20 meters deep over the Benguela current. Fog was frequent there, being especially dense and wet where the temperature was lowest, 12° C. near Luderitz Bay (lat. 27). Nearer the Equator, to latitude 9, cool weather with clear skies and light SW. winds was typical along the coast.

The NE. trade, which was investigated in the same season a year later, was found to be stronger but less

[1] Berichte der Deutschen Atlantischen Expedition, I-IV. By F. Spiess, G. Wüst A. Schumacher, E. Hentschel, Otto Pratje, Freiherr von Recum, H. Wattenberg, J. Reger, E. Kuhlbrodt, C. W. Correns, A. Defant, G. Böhnecke, K. Quasebarth. Zeitschr. d. Gesellschaft für Erdkunde zu Berlin. 1926, p. 1-77, 209-272; 1927, p. 81-139, 251-338; photos, maps, diagrams.

Festsitzung zur Begrüssung der Expedition am 24. Juni 1927 veranstalted von der Notgemeinschaft der Deutschen Wissenschaft und der Gesellschaft für Erdunde zu Berlin. By L. Diels, F. Spiess, A. Defant, and F. Schmidt-Ott.

Cf. also the briefer account: Die deutsche allantische Expedition auf dem Vermessungs- und Forschungschiff *Meteor*.' By Spiess, v. Recum, Schumacher, and Kuhlbrodt. An. d. Hydr. u. Mar. Met., 1926, 54: 73-94, 393-399, and Köppen-Beiheft, 57-64; 1927, 55: [169], 245-248, photos, maps, diagrams.

NOTE.—"Die Meteor-Fahrt," by Capt. F. Spiess, a comprehensive popular book on the *Meteor* expedition, was published in Berlin in the autumn of 1928, by Dietrich Reimer (Ernst Bohsen); it contains 376 pages, 420 photographs, 34 diagrams, and 4 maps, including a large general map of the voyages.

[2] Presented in brief before the American Meteorological Society at Washington, D. C., Apr. 28, 1928.

[3] Steamship and auxiliary sails: Displacement 1,200 tons, length 75 meters, draft 4 meters, speed 9 knots, cruising radius 6,000 sea miles, crew 133.

cool than the SE. trade. The wind was particularly strong (20 m/s) where constricted between the Cape Verde Island. The same cool, foggy thin layer of air near the African coast was observed. Sixty miles from Dakar, for example, while the temperature in the trade wind on deck was 19° C. that in calm air at the top of the mast was 27° C. There was much dust and sand in the air near Africa. The clouds were less persistently St. Cu. and the sky cover rapidly changeable.

Between the trades and in a belt along the American coast in trade-wind latitudes the typical trade-wind temperature lid gave way to a condition of fairly uniform lapse rate at 0.6° C. to the greatest heights reached. Here heavy showers occurred now and then, in marked contrast to the almost daily very light showers of the trades. In a narrow belt, from the mouth of the Amazon to the Gulf of Guinea, the rains were heaviest, and occurred almost daily. Near Para the weather in April was particularly damp and rainy. On the African side, thunderstorms were very numerous and were at times attended by strong squalls. In mid Atlantic the cooler countercurrent (2–3° N.) between the equatorial currents was marked by a belt of cool air, (23½° C.) high pressure (761 millimeters) and calm, while warmer low-pressure belts (both 757.8 millimeters) were near by at latitude 5° north and south. Rains were particularly heavy north of the high-pressure belt.

Table I gives in brief numerical form some of the climatic conditions found on the several profiles, which here are arranged according to latitude to facilitate comparison. This table was gleaned chiefly from the running account by Captain Spiess.

TABLE I.—*Certain climatological data for different latitudes on the Atlantic Ocean between 64° S. and 19° N.*

Profile	Latitude		Dates (1925–1927)	Number of days	Temperature			Relative Humidity			Cloudiness	Precipitation			Pressure		Wind velocity		
	Mean	Extreme			Mean	Maximum	Minimum	Mean	Maximum	Minimum		Days	Total	Maximum days	Maximum	Minimum	Mean	Maximum	Gales
					°C.	°C.	°C.	Per cent	Per cent	Per cent	Tenths	Per cent	Mm.	Mm.	Mm.	Mm.	M/s	M/s	Days
V Ewd	55° S	34°–64° S	Jan. 22–Mar. 8, 1926	45	2.9	8.0	0.2				9			12	767	727	(8)	20	(4+)
III Ewd	48° S	34°–52° S	Sept. 19–Oct. 25, 1925	36	4.3	9.0	0.0				8	78					10	30	6
I Ewd	41° S	40°–42° S	June 4–July 12, 1925	38	8.4	14	4				7	91					12	40	15
IV Wwd	33° S	32°–34° S	Nov. 12–Dec. 7, 1925	26	16.8	22.2	11.6				7.4	65	71	34	770	745	9.3		6
II Wwd	29° S	27°–30° S	July 28–Sept. 5, 1925	39	17						5	36					7	20	4
VII Ewd	23° S	22°–24° S	July 8–29, Aug. 12–15	26	19.6		13	72			5½	58	54	50	770	(763)	7	(12)	1
VI Wwd	16° S	15°–34° S	Apr. 22 and May 3–June 8, 1926	46	22.9		12	71			5½	57	35	22	765	760	6	11	
VIII Wwd	9° S	8°–13° S	Aug. 29–Sept 27	29	22.8	25	21	76			6	38	6	3	763	760	6.7	14	
XI Wwd	3° S	8° S–4° N	Dec. 16, 1926–Jan. 10, 1927	25	25	27.5		(80)	84	75	(5)	[1]		32	759	756.5	(7)	12	
X Ewd	3° N	Eq.–8° N	Nov. 10–Dec. 2, 1926	23	26.2	30	(24)	82			6	39	68		760	757.7	5.2	9	
IX Ewd	3° N	6° S.–10° N.	Oct. 10–30, 1926	21	26.6	28.5	23.5	80			6		124	60	761	757.8	5.6		
XII Ewd	7° N	2° S.–15° N.	Jan. 29–Feb. 22, 1927	25		27.5	18	80			(6)		(61)		762	758	7.5	20	
XIV Ewd	11° N	1° S.–19° N.	Apr. 19–May 5, 1927	17		(27)	20	80	87	68	6	[1]		54	763	758	(8)		
XIII Wwd	14° N	1° S.–19° N.	Mar. 3–10, Mar. 16–Apr. 6	30	(24)	27	17	(80)	90+	58	6	[1]		55	766.5	758	9	17	1

[1] Almost daily.

NOTE.—Figures in parentheses are incomplete or approximate.

The expedition returned to Germany late in May, 1927, successfully concluding their voyages of two years two months over 67,500 sea miles.

THE SPECIAL OBSERVATIONS

Evaporation observations by Dr. A. Schumacher were carried on under difficulties, but every effort was made to obtain measures of this climatic element which also shows the exchange between sea and air. No previous observations had been made in the eastern South Atlantic nor in high southern latitudes. Two evaporation vessels were used near each other. One was a cylindrical vessel with a long, narrow, cylindrical reservoir, and the other was a simple cylinder. (See figs. 61 and 143 in Captain Spiess's new book, mentioned at end of footnote 1.) Both were filled with 2,500 cubic centimeters of seawater. The surfaces exposed were 290 and 330 square centimeters. The surface temperatures of the water were obtained by a knitting-needle type of thermometer; temperature and humidity by Assmann aspiration psychrometer, wind velocity by hand anemometer, both inside and outside the vessels. Occasionally the air movement was only estimated. The evaporimeters were fixed on the stern, both starboard and port sides. Close by the starboard vessel was a Hellman recording rain gage. The exposure was bad only in a calm or with light head wind, when soot fell on the instruments. The shrouds and booms sheltered this area least. A few 12-hour determinations of evaporation were made, but mostly the 24-hour values were observed, 8 a. m. to 8 a. m. in the middle and higher latitudes and daily at 6 to 7 a. m. in lower latitudes. The evaporation from the two pans differed by a few tenths to half a millimeter, but the differences were not systematic. Individual values were found to be of the same order as those of earlier series. The interferometer method for determination of chlorine content calibrated by chlortitration was used where the waters were cool, with an accuracy of within 0.2 millimeter of evaporation, and the chlortitration method direct was employed for the warmer waters. All things considered, the chlortitration method was found better for use at sea, though the interferometer method was quick and reasonably accurate.

Comparative meteorological observations were made at 8 and 11 a. m., 2, 5, and 8 p. m., and 2 a. m. Wind velocity, air temperature, and humidity, and temperature of the water in the evaporimeter. The full diurnal course of these elements was then obtainable by interpolation from the recording instruments.

Both evaporimeters were considered as standards, the simple type because it was easiest to use and the other because its smaller range of temperature and humidity simulated more closely the actual sea-surface temperature. The older, more complex type was employed chiefly to provide values comparable with observations of previous expeditions.

In quiet weather a small boat was lowered for observations that would give the actual rate of evaporation from the sea. The temperature of the surface film of the sea down to very small depths was made with a precision thermometer with a fine knitting needle form of bulb. Air temperatures and humidities were obtained at 0.1 and 1 meter above the surface with the Assmann instrument, and on the ship at 5 and 8 meters. For continuous

temperatures of the general surface layer of the sea an electrical resistance thermometer recorded intake temperatures (except when corrosion of the tube had rendered it useless).

Of the 320 observations two-thirds were undisturbed by rainfall; light precipitation had to be taken into account in others, and several were computed from the meteorological data, owing to heavy rain. Observations from a small boat were made at 14 places. The data are most complete in the SE. trades, and there is in addition a fine set in the NE. trades. Also, an exceptionally good series was obtained in subpolar latitudes. Preliminary values indicate a daily evaporation of 5 millimeters in the Gulf of Guinea, and an average of 9 millimeter in the SE. and NE. trades, with a range in the trades from 4–6.5 millimeters over the cool water in the east to 8–12 millimeters over the warm water in the middle and west.

Hundreds of determinations were made of atmospheric oxygen, H ion, and carbon dioxide.

Meteorological observations in the lower layers were made with the instruments on a program of a station of the first order: Thermometers, 2 rain gages (1 with shield, see figs. 60 and 143 in book), evaporimeters (described above), radiation instruments, marine barometer (hung amidships at sea level), 3 barographs (tridaily, weekly, monthly), 2 hydrographs (2-day clock; one in use while other being cleaned of salt and soot), thermograph, Assmann aspiration psychrometer, 4 resistance thermometers (inside, on foremast, 28 meters up on stern mast, and in shelter), 3 anemometers on the masts (see fig. 66 in book), the highest at 31 meters, and, for part of trip, a recording wind vane. The thermometer shelter was freely exposed on the roof of the chart house 9 meters high. It was well ventilated in general. Outside the shelter the Assmann psychrometer was always used on the windward side of the bridge. In the Tropics dew formation on the inner contacts of the registering apparatus of the resistance thermometers made some records uncertain. The two meteorologists, Doctor Reger and Doctor Kuhlbrodt, made thrice-daily observations, at 7, 14, and 21 hours local time, of pressure, temperature, humidity, sea temperature, cloudiness (form and cover), wind direction and velocity, state of the sea, and visibility. The navigating officers on the bridge made 4-hour observations of the usual elements, and hourly of cloudiness, sea temperature, and wind.

Radiation measurements.—A Michelson and a Linke actinometer on the stable setting of the mirror theodolite (fig. 72 in book) could be used only occasionally, for the rolling and steering of the ship made it difficult to keep the sun long enough in the opening. A place out of the wind and out of the smoke train was also difficult to find. Obviously, most of the 65 series of observations (on 22 days) were made in low latitudes. A Robitzsch (sun and sky) radiation recorder set on gimbals on the quarterdeck was of little use in southern profiles, though many valuable records were obtained elsewhere. Sometimes the instrument had to be put away from boarding seas. There was much disturbance by smoke and the rigging. Nocturnal radiation in terms of sum totals for the entire night was measured by a tulipan. Wholly clear nights were rare.

AEROLOGICAL OBSERVATIONS

The aerological was the most important part of the meteorological program, for few such observations had been made before at sea, especially in the equatorial and South Atlantic. Professor Reger and Doctor Kuhlbrodt (figs. 9, 10, and 65 in book) had an arduous task, with their daily balloons and biweekly kite flying in addition to their other observations.

Pilot balloon ascents have the advantage of being independent of the motion of the vessel. Usually there were two ascents a day. To avoid clouds favorable moments were chosen and high ascensional rates (250–400 m/min) were used. The balloons (fig. 63 in book) were filled from tanks. The altitude and azimuth (from ship's axis) were followed with a mirror theodolite (fig. 65 in book), and the reading of the compass was noted with each observation. The distance of the balloon was measured with the distance measurer (range-finder principle.) (Fig. 64 in book.)[6] Most of the balloons disappeared in or behind clouds. The hundreds of cloud heights thus obtained are valuable. The smoke train ended many balloon observations. So did dense cirrus and dust haze near North Africa, though a red filter helped considerably. When the ship was going against the wind, the pitching made observations (always from the stern) appreciably more difficult. On occasions of rapidly changing clouds or strong winds smoke bombs (8.8-centimeter gun, fig. 39 in book) were used with the distance finder and mirror theodolite. The bombs were shot through holes in the clouds, and were observed up to over 7,000 meters and for 20 minutes at a time. Cloud motions were observed frequently, especially cirrus, to round out the aerological data. The mirror theodolite and distance finder were used for this, and double determinations were often made for checking. About 500 cloud photographs were taken.

Owing to low clouds and strong winds the heights reached by the balloons were generally low in the westerlies, and the average for Profiles I to V was but 3,560 meters. The St. Cu. sheet of the SE. trades also limited the heights attained. The more changeable clouds of the NE. trades, however, permitted better results, and the best were obtained in the western portions of Profiles XII to XIV, where the 41 ascents averaged 13,500 meters. In the equatorial zone ascents were often impossible because of continuing rain. Where ascents were made either dense low clouds limited the runs or early bursting of the greatly deteriorated balloons, even though less inflated than usual, brought them to an early close. After so much trouble near the Equator, heavier, double-ply balloons of about 430 grams weight were employed successfully. In spite of the equatorial troubles, the average for Profiles VI to XIV was 8,300 meters. The general bursting height was 18 to 20 kilometers, or well within the stratosphere. The greatest height reached was 21,100 meters. Altogether, there were 812 well-distributed pilot balloon ascents, which as a whole show the major air movements in the troposphere at least over the tropical South Atlantic and the air exchanges along the coasts.

Sounding balloons (figs. 38 and 62 in book) could be used but few times, owing to the generally low speed and restricted coal supply of the ship. The winds would have carried the balloons away faster than the ship could follow. By the time the latitudes of small wind were reached the deterioration of the rubber restricted the chances of success still further. In some cases the second of the two supporting balloons burst before the ship arrived. The instrument was lost in one. The sounding balloons did, however, make a valuable, though small, addition to the kite records.

[6] The balloons, distance measurer, and theodolite are described in some detail by Dr. E. Kuhlbrodt in the Köppen-heft of An. d. Hydr. u. Mar. Met., 1926, pp. 57–63. The theodolite is described in brief by Lieut. F. W. Reichelderfer in Bull. Am. Met'l Soc., 1928, 9:151–152.

Kite flying (figs. 67–71 in book) was highly successful. An electric motor and an effective brake were employed. Collapsible box kites, easy to land and requiring little space to store, were commonly used, but were found of untested stability and sank too readily if they fell into the sea. The landing field was but 8 meters long. An extra pulley on a gaff was found helpful in starting and concluding flights. In stormy weather the turbulence caused by the ship threw the kites about and made much trouble. Sometimes kites were sent up without instruments, to get the wind at least. The limited coal often meant limited kite flights. None were possible when sails were set, for the lee whirl throws a kite into the water. The numerous flights in the stormy westerlies were possible because of the large wire used, which, however, could not be lifted high.

The lighter trade winds permitted a finer wire: 1,800 meters of 0.7-millimeter, 4,000 meters of 0.8-millimeter, 6,000 meters of 0.9-millimeter, and an outrun of 100 meters of 0.8-millimeter wire. The supporting surface of the instrument kite and one or two others was 8 square meters. These large kites proved better than 5 square meter kites in strong winds, for the latter lie on a side during hard inpulling. The formation of kinks by the pulley system caused the loss of three instrument kites. Frequent renewal of the top 1 or 2 kilometers of wire is advised. The loss of meteorographs necessitated the use of balloon meteorographs on the last three profiles. These were slung on wires 5 meters long attached 130 to 140 meters back of the leading kite, far enough for the kite to be free of the ship's eddies. Owing to pendulation of the instrument, the sun when high affected the temperature indications. Good results were obtained in two ascents after sunset. Flights could be made when the wind relative to the ship was 6 m/s or more.

Of the 217 kite flights, 150 were in the Tropics. Frequently no ascents could be made in the westerlies because of storms. On Profiles III and V ice frequently formed on the wires, holding the kites down. The maximum heights attained were in Profile IX in the equatorial zone. On the whole, the so-called calm belt was a fruitful field for kite flights. There were 33 between 4° N. and 4° S., and of these 14 exceeded 3,000 meters and 4 went over 4,000 meters. The average altitude reached in the 217 kite flights was 2,200 meters and the maximum, 4,870 meters.

CONCLUSION

The foregoing summary of the work of the *Meteor* expedition tells a story of heroic labors in the interest of science. Such a large volume of data was collected with the utmost scientific care that the final results of study can not fail to be highly illuminating. First, there will be a notable contribution to the climatology of the Atlantic. Altogether, an unbroken record of pressure, air temperature, humidity, wind direction, wind velocity, and precipitation was kept throughout the 26 months' voyage. Hourly values for cloudiness, state of the sea, and water temperatures were also obtained for the entire period at sea. The extensive evaporation measurements and the considerable series of radiation observations also deserve special mention. Second, there will be the most extensive contribution ever made by a single expedition to knowledge of the temperature, humidity, and circulation of the atmosphere. These aerological observations were made at all seasons and in large number and cover in a fairly uniform way the entire width of the South Atlantic Ocean near the Antartic Continent to the Equator and the portion of the North Atlantic which is between South America and Africa. Tropical wind variability was found to be greater than supposed; winds at all heights vary considerably, and there is no antitrade in the old sense.

There could be no better memorial to Doctor Merz than the monumental results that will come from this remarkably successful expedition, planned by him and begun under his direction, and carried through with competence and indefatigable zeal.

EDITORS OF THE MONTHLY WEATHER REVIEW

By A. J. HENRY

The first issue of the MONTHLY WEATHER REVIEW was that of October, 1872, rather than January, 1873, as frequently hitherto given. The first issue was reprinted in the annual report of the Chief Signal Officer for 1873, page 981. This issue contained less than 1,500 words and a single chart, viz, one showing the paths of cyclonic storms for that month. The late Prof. Thompson B. Maury with the assistance of Observer-Sergt. Henry Calver,[1] was responsible for the first issue. Mr. Calver, who joined the Signal Service in 1871, suggested to General Myer in August of that year the issue of a weekly review of the weather for the benefit of the press and commercial organizations. He was commissioned to prepare and issue such a report and doubtless the idea of a monthly review grew out of Calver's weekly report for we find that Professor Maury, with whom Calver served, to have been responsible for the first issue.

Strange as it may seem there is no official record of the responsible editors of the REVIEW during the régime of the military weather service; it was the custom at that time for the official who had served as "indications" officer to have editorial charge of the MONTHLY WEATHER REVIEW during the month immediately following his tour of duty on the indications work as it was then called.

It is not now possible to give a categorical list of the early editors more than to say that the work was divided among the civilian professors, Abbe and Maury, and the following-named Army officers who had been detailed for service in the Signal Service of the Army, viz, Craig, Dunwoody, Greely (later Chief Signal Officer), Story, Powell, Allen, Thompson Glassford, Finley and possibly others, including the late Prof. Henry Allen Hazen, who took up the work in September, 1887.

Effective in July, 1891, when the weather service was transferred to the Department of Agriculture and the present Weather Bureau was created, the editorship of the REVIEW was vested in a board of editors composed of Mr. Horace E. Smith, chief clerk of the Bureau and Profs. Russell, Hazen, and Marvin together with Edward B. Garriott, who served as the actual editor during the life of the board.

In July, 1893, Prof. Cleveland Abbe was named as editor and it is to him more than any other person that the publication reached its high standing as a meteorological journal.

In July, 1909, a radical change was made in the scope and form of the REVIEW. The United States was divided into 12 major subdivisions on the basis of the

[1] Mr. Calver, a successful patent attorney still practicing his profession in Washington, D. C., has the distinction of being the sole survivor of the Signal Service central office of 1871.—ED.

water partings of the larger river systems, and the printing of the daily precipitation for some 5000 stations was undertaken. Inasmuch as charge of the rainfall stations was vested in the climatological division, the chief editorship was given to the late Prof. Frank H. Bigelow, who was assisted by 12 editors, drawn from the field service, one for each district. On Professor Bigelow's resignation from the Federal Weather Service in 1910, his successor in charge of the climatological division, P. C. Day, assumed the editorship.

The new form of the REVIEW was abandoned in December 1913, and the publication with some minor modifications reverted to the form which it has held from 1893 to 1909. Professor Abbe resumed his former position as editor and continued as such until he was forced by ill health to surrender it to his son Cleveland Abbe, jr., in July, 1915.

The tabulation below presents in convenient form the succession of editors up to the present.

Periods	Names
October to December, 1872	Thompson B. Maury.
January, 1873, to July, 1891	C. Abbe and others.
July, 1891, to July, 1893	Editorial board consisting of H. E. Smith and Profs. Russell, Hazen, and Marvin with E. B. Garriott as actual editor.
August, 1893, to July, 1909	C. Abbe.
July, 1909, to July, 1910	F. H. Bigelow and 12 district editors.
August, 1910, to December, 1913.	P. C. Day and others.
January, 1914, to June, 1915	C. Abbe.
July, 1915, to June, 1918	C. Abbe, jr.
July, 1918, to May, 1919	H. H. Kimball, acting.
June, 1919, to April, 1921	Charles F. Brooks.
May, 1921	Alfred J. Henry.

NOTES, ABSTRACTS, AND REVIEWS

The Stratosphere over North India.—Ascents of sounding balloons carrying Dines meteorographs carried out from the Upper Air Observatory, Agra, during the last two and a half years have yielded interesting information regarding the height and temperature of the base of the stratosphere over northern India and their remarkable seasonal variations. A brief summary of the results may be of interest.

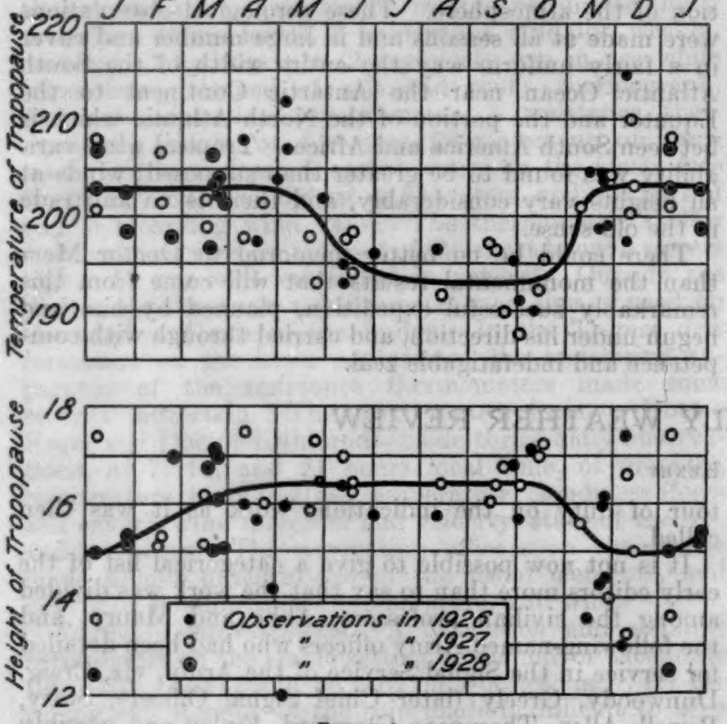

FIGURE 1

All the three types of transition from the troposphere to stratosphere classified by W. H. Dines, namely, Type I. When the stratosphere commences with an inversion; Type II. When the stratosphere begins with an abrupt transition to a temperature gradient below 2° C. per kilometer without inversion; and Type III when the decrease of lapse-rate takes place gradually; are met with. In addition, a fourth composite type with I above II or III is common between the months November to April.

During the period April, 1926, to March, 1928, 46 records of ascents to the stratosphere are available. The mean height of the tropopause (H_e) is 15.9 geodynamic or 16.3 ordinary kilometers and the mean temperature (T_e) 199° A.

In Figure 1 are plotted the heights and temperatures of the tropopause obtained from the records of these ascents. When the transition is of the composite type, both positions of rapid changes of lapse rate are plotted. The sudden jump of temperature and height of tropopause between October and November is specially noteworthy, as it occurs more than a month and a half later than the time of withdrawal of the monsoon from north India. From the point of view of seasonal variation, we may divide the year broadly into two parts—

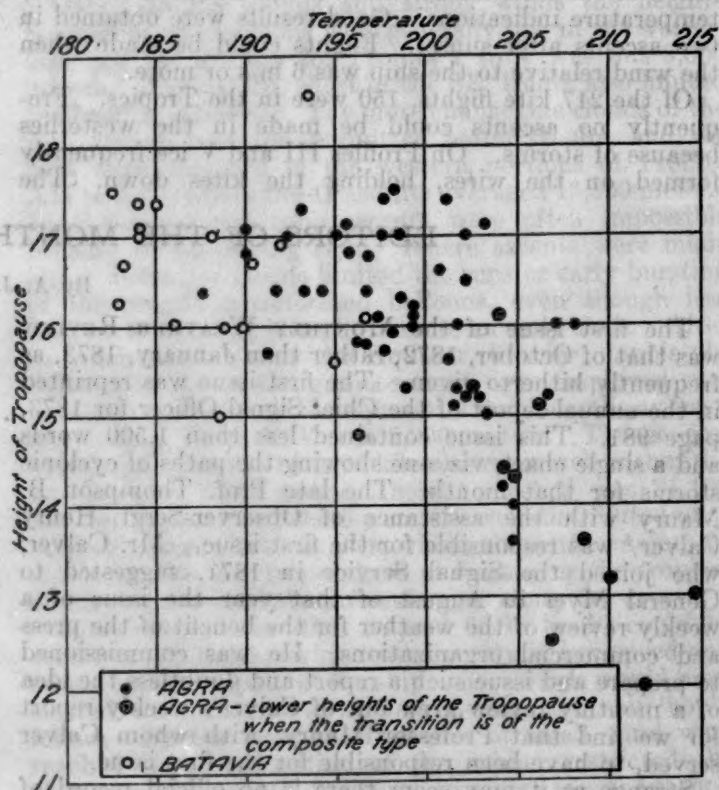

FIGURE 2

(1) *Middle of May to end of October.*—During this period, the type of tropopause is either I or II; if II, the initial sudden change of lapse rate is followed by an inversion soon after, so that there is always an inver-

sion of temperature in the stratosphere. The mean value of the height of the tropopause is 16.5 geodynamic kilometers, and its mean temperature 194.5° A. The period of activity of the monsoon in northern India is July to September.

(2) *November to middle of May.*—In this period, Types III and IV are more frequent. Even here there is almost always an inversion of temperature above 17 geodynamic kilometers. The mean values of H_c and T_c during this period are 16.2 gkm. and 201° A. if we take the values corresponding to the higher value of H_c on occasions when the transitions were of type IV, and 14.9 gkm. and 203.5° A. if we take values corresponding to the lower values of H_c.

A significant feature shown by the results of the monsoon period is the comparatively high temperature between 4 and 13 gkm. and the close agreement of the height-temperature lines between these limits with those of saturation adiabatics.

In Figure 2 are shown the values of T_c plotted against the corresponding values of H_c. The values obtained by Van Bemmelen from ascents at Batavia are also plotted for comparison. The general tendency of H_c to approach a limiting value of about 17.5 gkm. with decreasing T_c is very suggestive.—*K. R. Ramanathan, Meteorological Office Poona, October 12.*

Cours de Physique, Troisième Partie, Aérologie et Aérodynamique. By E. Rothé (Gauthier-Villars, Paris, 1928).—This book is an elementary treatment of the sciences of aerology and aerodynamics based largely on the lectures of Professor Rothé at the Aerodynamic Institute of the Faculty of Sciences at Nancy and at the Geophysical Institute at Strasbourg. The publication of the part on aerodynamics was interrupted by the war in 1914 and although the original manuscript was revised, the revision appears to have consisted mainly of the addition of the Strasbourg lectures on aerology. There are exceedingly few references to work in aerodynamics carried out after 1914. Unfortunately, aerodynamics has advanced so rapidly that experiments made prior to 1910 are obsolete, because models were too large, the interference of supports was excessive, the airstreams were nonuniform and turbulent, and instruments and experimental technique were, according to present day standards, primitive. The book of Professor Rothé represents in general the state of the science in 1914 rather than in 1928. Dimensional coefficients are used instead of the nondimensional coefficients which have been in use almost universally for several years. The value given as the result of the most precise "modern" experiments on the resistance of flat plates is about 20 per cent too high. The only aerodynamic balance described is the obsolete Eiffel balance. Such examples could be multiplied.

An entire chapter is devoted to the so-called paradox of Dubuat. In 1786 Dubuat published an account of experiments on plates towed in still water and immersed in running water, in which a difference of about 30 per cent was found, depending on whether the plate or the water was moving. Notwithstanding the fact that both results are considerably in error because of the use of an inaccurate anemometer for the measurement of the speed of the flowing water, because of the interference of large supports, and of an inaccurate method of obtaining the total force from pressure measurements, this "paradox" and its many "explanations" are often quoted by engineers as showing that the forces on bodies in fluids depend on whether body or fluid is moving. Professor Rothé quotes an "explanation" given by Joukowski in 1916 that the difference was due to turbulence in the flowing water, and describes confirming experiments in which plates are moved in a tube just a little larger than the plate. According to the best of our knowledge, the flow around a thin flat plate in a large stream is not very sensitive to the amount of turbulence present, and turbulence has no place in an "explanation" of the Dubuat "paradox." The effects of turbulence are felt only in bodies of curved outlines such as spheres, cylinders, ellipsoids, airship hulls, etc.

Notwithstanding the fact that Professor Rothé's book is not suitable for beginning the study of aerodynamics, the advanced student will find a number of the older experiments brought together in a convenient place and will find much of historical interest in the book.—*H. L. Dryden, Physicist.*

The diurnal variability of humidity in northwestern Washington (by George W. Alexander).—Author's Abstract: An attempt was made to discover whether or not there is any consistent relationship between relative or absolute humidity, as indicated at the morning (5 a.m. Pacific time) observation and the percentage of relative humidity (degree of fire hazard) during the afternoon of the same day. The results were altogether negative.

Over a total of 8,268 dates it was found that low relative humidity in the afternoon was preceeded by normal relative humidity in the morning in 67 per cent of the cases and by near normal conditions in an additional 21 per cent. Greatly subnormal relative humidity at morning observation was of rare occurrence, and usually marked the culmination rather than the beginning of a period of "fire weather." Even the lowest percentages in the afternoon frequently followed abnormally high morning percentages.

The absolute humidity, as represented by the temperature of the dew point, was normal or near normal on 88 per cent of days with subnormal relative humidity in the afternoon. There is a tendency for variation in the absolute humidity, the dew-point temperature and the relative humidity each decreasing in 38 per cent of these days. In April, May, and September east winds cause abnormally low absolute and relative humidities simultaneously three or four times each year; in midsummer most cases of low relative humidity are due to increases in temperature.

The conclusion is expressed that, for this section at least, morning humidities can not be used effectively as arguments in the development of empiric formulæ for determining the percentage of relative humidity during the following afternoon, and that the determination of the nature and extent of changes in humidity must be based on a proper interpretation of the weather map.

Arctic exploration.—Sir Hubert Wilkins, speaking before the British Empire Chamber of Commerce, in the Whitehall Club in New York on March 20, 1929, outlined a 10-year plan to establish 12 weather-observing stations in the Antarctic and sub-Antarctic for the betterment of weather forecasting. Sir Hubert, it may be remembered, made an airplane flight from Point Barrow, Alaska, to Spitzbergen in April, 1928.

According to the report of the luncheon as printed in the New York Times of March 21, 1929, Sir Hubert is reported as saying:

> The plan that has been before the Meteorological Society now for a number of years is this: We shall lay down in the Arctic some

30 more stations than there are at present and that work is now in the hands of a society known as the Aero-Arctic Society with headquarters at Berlin and subscribed to by every Government in the Northern Hemisphere without exception. * * * The plan for investigation at the polar regions is not going to open the way in itself to accurate meteorological forecasting, but it is going to help if we can collect our information and correlate it with that which has already been gathered from other parts of the world.—(*Excerpted from the New York Times of March 21, 1929.*)

Flying weather over Greenland.—Prof. William H. Hobbs, director of the University of Michigan Greenland expeditions, is a strong advocate of the Greenland air route between America and Europe, which offers the great advantage of avoiding the long "hops" of more southerly routes and also of passing to the northward of the fog-ridden Newfoundland Banks. The route he recommends starts at Chicago, crosses British America to Cape Chidley, spans the relatively narrow Baffin Bay to to the west coast of Greenland, crosses the inland ice of Greenland to Angmagsalik, on the east coast, continues thence to Reykiavik, Iceland, and then crosses to any desired point in northwestern Europe. Concerning certain climatic features of this route he says:

Over Greenland, and particularly over the great dome of inland ice, fogs are exceedingly rare, if we except the shallow near-surface stratum of the remote Greenland interior. This zone of mist and fine snow may constitute a serious handicap, in that ice may form on the fuselage. It is believed, however, that this dangerous zone can be avoided by flying at a height of a few hundred feet above the flat surface of the dome, which is at a level of about 9,000 feet.

The glacial anticyclone located permanently over the inland ice consists of upper currents moving in toward the center, there settling to the ice surface, and passing out centrifugally toward all margins. It is therefore only necessary for the pilot to ascend a few thousand meters so as to enter the upper currents and proceed to the center with a tail wind, and, after crossing the central region, to descend into the surface current and go out with a tail wind. This circulation can be used as well on the westward as on the eastward journey.

The surface of the inland ice, except near its margin, is nearly as level as a ballroom floor and is also hard enough for landing with wheels or skis within broad zones on either side.—*C. F. Talman, in Why the Weather? Science Service, March 19, 1929.*

French meteorological activity, 1928.—In the Finance Committees' report to the 1929 Air Budget, General Hirschner outlines the work of the meteorological service for 1928, as follows:

The requests for regular meteorological reports pertaining to air navigation have steadily increased during 1928. The information desired pertained particularly to long-distance flights, thus complicating the gathering and dissemination of information. During the period from May to August, for example, the number of reports to various meteorological stations averaged from 50 to 60 per day and required messages aggregating some 2,500 words.

Meteorological information was divided into three general classes—that for civilian air lines, flights undertaken by either the military or naval air services, and long-distance flights.

CIVILIAN AIR LINES

Nine civilian air lines were organized during 1928 * * *. To cover completely this increasing number of air lines it was necessary to create auxiliary posts (gendarmerie, airdrome caretakers, etc.) for simple observations which, nevertheless, required careful checking. On certain lines, the service starts very early in the morning, necessitating observations during the night and at daybreak. It was necessary to arrange with the various departments, particularly the auxiliary services, and to obtain permission to use personnel for gathering and transmitting the information. The situation is particularly complicated since our regular lines are practically all international in character. This requires close liaison between meteorological services of the interested countries.

MILITARY FLIGHTS

These may be classified as follows: Individual flights, formation cross-country flights, and night flights. The protection of individual flights is assured by the normal system of information. Usually the pilots on such individual flights are experienced men who are capable of coping with difficult meteorological situations.

Formation cross-country flights necessitate a much closer control and the information furnished must be more complete. Additional means of transmission are thus necessary and in preparation for such flights rather complicated orders may be required. The importance of meteorological information can not be too greatly stressed. In spite of the great progress which has been made, two serious accidents occurred during 1928 which might have been evaded. A pilot left an eastern airdrome during local clear weather but became lost in a fog which covered a great part of France. He was forced down and in landing his plane turned over. A squadron flying in formation left an eastern airdrome under good local weather conditions but met with a series of violent storms which had been forecast and reported by the Meteorological Bureau. The squadron was dispersed and partly destroyed.

NIGHT FLIGHTS

Until 1927 night flying was restricted to the areas over Chartres and Nancy where the night bombarding regiments are stationed. During 1928, however, individual and formation night flights took place over the whole of France. This necessitated in many cases a special meteorological organization, since the last information received, in the normal network, is at 6 p. m. It was impossible to exact too much night work of personnel required to make early morning observations.

Since training in night flying will continue, it will be necessary to provide adequate funds to make the night meteorological service effective.

LONG-DISTANCE FLIGHTS

These flights generally pass beyond the limits of France and sometimes those of Europe. They usually begin early in the morning and are often postposed from day to day. This imposed a great responsibility upon the meteorological service. * * *

SCIENTIFIC STUDIES

The method of forecasting weather conditions has undergone very marked improvement, thanks to the work of our meteorologists and those abroad. Meteorological studies in connection with trans-Atlantic flights have had an important effect on the study of the atmosphere over the ocean. * * *

HIGH ATMOSPHERE

The Trappes Observatory continued its work on the temperature, pressure, and hygrometry of the high atmosphere. Balloon observations were made, either in conjunction with international soundings, or at favorable times and in connection with special studies. As a general rule, twin balloons were used since they are easier to locate after landing, and in addition will carry more complete equipment consisting of the baro-thermo-hygro, and other apparatus.

INTERNATIONAL RELATIONS

International collaboration is essential in meteorology. Numerous conferences and international congresses have taken place during 1928. These may be divided into three groups: Conferences on purely meteorological subjects; Air conferences with meteorological commissions; radio conferences.

Meteorological conferences.—Certain of these are scientific and pertain to the unification of methods which are essential to the development of the science. (Commission for the exploration of the high atmosphere which met in 1927 at Leipzig; Session of the International Geodetical and Geophysical Union which met in Prague in 1927.) Others concern the organization necessary for the transmission of radiograms. (Commission for the radio-meteorological organization over the sea which met in London in 1928).

The first of these conferences, presided over by the Director of the National Meteorological Bureau, began a complete organization for radiometeorological observations at sea and particularly over the Northern Atlantic. The second treated of the problems incident to the functioning of the world's radiometeorological network and prepared a new code for the transmission of meteorological observations. These two conferences were the first to be attended by representatives of the American meteorological service since the war.

Aeronautical conferences.—The proper functioning of international air lines necessitates periodical conferences which deal with

the many questions pertaining to the exploitation of these lines. The organization of the meteorological service requires modification in accordance with new extensions of the international air lines and to cope with new problems. The latest aeronautical conferences have prepared a general program of radiometeorological liaison which will permit of unlimited development of air activity.

Radio conferences.—Meteorology, particularly aviation meteorology, is very dependent upon radiotelegraphy. However, the radio facilities are not sufficient to handle all of the traffic. This necessitates international agreements for the redistribution of wave lengths. The radiotelegraphic conference held at Washington has entirely modified the international radio chart, which dated from 1912. For the first time, international meteorology was represented, and one of these representatives was a Frenchman. Meteorology has obtained in the new international radiotelegraph regulations a place corresponding to its essential needs. * * *

DEVELOPMENT OF THE WORLD'S NETWORK

The development *in length* of long-distance flights and of the great international lines entails a development *in area* of information received, and since meteorological observations throughout the world must take place at the same time and since the transmission of the information must be as rapid as possible it becomes necessary to concentrate during certain hours information gathered from one-third the surface of the globe. For lack of appropriate means, the bureau had to resort to technical means not yet in general use.

Several meteorological radiograms are received daily from America. These are made possible by the powerful sending sets in use in America and the excellent reception in France. Unfortunately, due to the poor sending facilities placed at our disposal and the difficult condition of reception in America, we have been unable to effect a proper exchange. America is sending us daily more than 600 words and has received nothing from us. This is an abnormal condition which can not last indefinitely.

Adequate radio communication with America is essential. So far no expenditure has been made for this purpose and only existing means have been available. If improvements which are to be made in the military stations on the Eiffel Tower and at Issy-les Moulineaux are not sufficient to solve this problem, money must be appropriated to create the necessary technical means.

Actually, the use of long and of short waves permit the reception in Europe of American information. The situation is not quite so favorable with respect to information at sea. The collaboration of France in "ship's observation" would be very meager were it not for the *Jacques Cartier*. Notwithstanding means utilized since 1921, and the free assistance given by the French Line and the Radio-Maritime Co., it has been impossible to obtain satisfactory transmission by coast stations of meteorograms sent from French ships over the North Atlantic. The bureau first used the naval stations but they could not assure liaison with commercial ships, for various reasons. The bureau then tried to transmit its radiograms by the postal stations along the coasts, paying the entailed expenses, but without satisfactory results. This situation must be remedied if France is to play its part in the vast program established by the International Commission for the Meteorological Organization at Sea. * * *

(*Prepared under the direction of Brig. Gen. William W. Harts, military attaché at Paris.*)

Meteorological summary for Chile, January, 1929 (by J. Bustos Navarrete, Observatorio del Salto, Santiago, Chile).—January, 1929, was characterized by unusually high temperatures in the central and southern zones especially between the 15th and 20th; maximum temperatures exceeded 86° between Santiago and Valdivia and at the close of the period 95° was recorded at San Fernando and 100° at Talca.

During the first half of the month atmospheric activity was practically at a standstill even in the south; no rain fell at Valdivia.

On the 18th a reaction set in with a depression crossing the extreme south and bringing scattered rains as far as Corral; then from the 24th to the 26th another depression influenced the weather in the southern zone with unsettled weather occurring between Valdivia and Chiloe.

On the 29th there suddenly appeared from the west, in about latitude 45° south, a marked cyclonic area (barometric minimum 29.13 inches) similar to those of midwinter; this depression affected a considerable area. The storm began in the south late on the 29th and extended to the remainder of the country on the 30th, bringing high north winds and abundant rainfall from Magallanes to Aconcagua. The unsettled weather abated on the 31st. The amounts of precipitation ranged from 0.80 to 1.20 inches in the central zone to 1.60 to 3.90 inches in the southern zone.

Anticyclonic centers were practically absent; the only ones meriting mention were charted on the 4th over Chiloe and on the 23d over the Juan Fernandez Islands.—*Translated by W. W. R.*

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SOLAR OBSERVATIONS

SOLAR RADIATION MEASUREMENTS MADE DURING FEBRUARY, 1929

By HERBERT H. KIMBALL

For references to descriptions of instruments and exposures, and an account of the method of obtaining and reducing the measurements, the reader is referred to this volume of the REVIEW, January, page 26.

Table 1 shows that solar radiation intensities averaged close to normal values for February at Washington and Madison and considerably below at Lincoln.

Table 2 shows an excess in the total radiation received on a horizontal surface at Washington, Madison, New York, and Chicago, and a deficiency at Lincoln.

Skylight polarization measurements obtained on two days at Washington give a mean of 63 per cent with a maximum of 64 per cent on the 4th. These are slightly higher than the corresponding averages for February at Washington. No measurements were obtained at Madison, as the ground was continuously covered with snow throughout the month.

TABLE 1.—*Solar radiation intensities during February, 1929*

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass, A. M.					Air mass, P. M.				Local mean solar time
	e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Feb. 1	1.68		0.54	0.75	1.13		1.23	1.00	0.80		1.37
Feb. 4	1.88	0.70	0.86	1.06	1.29	1.56	1.26	1.01	0.87	0.73	1.96
Feb. 7	4.75	0.73	0.87	1.03							4.37
Feb. 11	1.88						1.03				1.68
Feb. 12	1.88		0.65	0.75	1.05		1.28	1.04	0.87	0.73	1.37
Feb. 18	4.57	0.64	0.83	0.96	1.26						4.75
Feb. 23	1.52		0.72	0.96	1.22						1.32
Means		0.69	0.74	0.92	1.19	(1.56)	1.20	1.02	0.85	(0.73)	
Departures		−0.02	−0.06	−0.05	+0.02		+0.01	+0.05	+0.01	−0.03	

TABLE 1.—*Solar radiation intensities during February, 1929*—Con.

Madison, Wis.

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass, A. M.					Air mass, P. M.				Local mean solar time
	e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Feb. 1	0.48	1.02	1.12	1.27	1.40						0.86
Feb. 2	0.81			1.16							1.12
Feb. 9	0.58		1.06	1.23	1.43						0.86
Feb. 11	0.71		0.88	1.05				1.06			1.19
Feb. 15	1.68	0.92	1.04	1.15							2.87
Feb. 19	0.51						1.44				0.53
Feb. 20	0.28				1.35						0.71
Means		(0.97)	1.03	1.17	1.39		(1.44)	(1.06)			
Departures		+0.02	−0.07	−0.05	+0.02		+0.07	−0.12			

Lincoln, Nebr.

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
Feb. 9	0.38		1.10	1.27	1.43		1.43	0.91	0.65		0.66
Feb. 10	1.19		1.08	1.24	1.38						1.45
Feb. 11	0.86			0.82	1.32						1.24
Feb. 13	0.96							0.98			1.37
Feb. 15	2.26						1.50	1.19	1.05	0.93	2.36
Feb. 16	2.49				1.38						4.17
Feb. 19	0.71			0.99	1.25						0.86
Feb. 20	1.02	0.88	0.97	1.15	1.34						1.88
Feb. 22	1.12	0.91	1.05	1.17	1.31	1.61	1.39	1.11	1.03	0.83	2.36
Feb. 26	2.16							1.10	0.98	0.91	2.87
Feb. 27	2.16	0.61	0.77	0.94	1.27						3.00
Means		0.80	0.99	1.08	1.34		1.44	1.06	0.93	0.89	
Departures		−0.13	−0.05	−0.12	−0.04		+0.08	−0.11	−0.10	−0.03	

[1] Extrapolated.

TABLE 2.—*Total solar radiation (direct + diffuse) received on a horizontal surface*

[Gram-calories per square centimeter]

Week beginning	Average daily radiation: Washington	Madison	Lincoln	Chicago	New York	Fresno	Average daily departure from normal: Washington	Madison	Lincoln	Chicago	New York
1929	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Jan. 29	279	224	135	124	211	213	+77	+31	−92	+39	+71
Feb. 5	176	251	258	134	145	329	−25	+42	−1	+10	+16
Feb. 12	272	219	277	150	188	361	+47	−10	−7	+11	+50
Feb. 19	323	265	283	165	212	402	+67	+12	−24	+9	+32
Excess or deficiency since first of year on Feb. 28							+945	+203	−1,876	+399	+1,036

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. C. S. Freeman, Superintendent U. S. Naval Observatory. Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, and Mount Wilson Observatories. The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column]

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longitude	Latitude	Spot	Group	
1929	h. m.	°	°	°			
Feb. 1 (Naval Observatory).	11 58	−68.5	153.1	+7.5		31	
		−58.5	163.1	+5.0		46	
		+20.5	242.1	−5.5		170	
		+80.0	301.6	+8.0	77		324
Feb. 2 (Naval Observatory).	11 44	−54.0	154.5	+7.0	31		
		+30.0	238.5	−16.5		62	
		+34.0	242.5	−5.5		201	294
Feb. 3 (Naval Observatory).	11 43	−37.5	157.9	+6.5		31	
		+46.0	241.4	−16.5		22	
		+49.0	244.4	−6.5		93	146
Feb. 4 (Naval Observatory).	11 41	−73.0	109.2	−9.0		108	
		−65.0	117.2	+9.0		37	
		−27.5	154.7	+6.5		77	
		+60.0	242.2	−16.5		77	
		+64.0	246.2	−6.5		62	361
Feb. 5 (Harvard)	15 8	−53.0	114.5	−9.0	153		
		−45.0	122.5	+8.0		32	
		−10.5	157.0	+7.0		123	308
Feb. 7 (Naval Observatory).	11 38	−69.5	73.2	+9.5	46		
		−63.5	79.2	−4.5	123		
		−57.5	85.2	−10.5		448	
		−30.0	112.7	−8.5		123	
		−19.0	123.7	+7.0	9		
		−14.0	128.7	−10.0	6		
		+13.5	156.2	+7.5		139	
		+59.5	202.2	−20.0	12		
		+65.0	207.7	−9.5		62	968
Feb. 8 (Naval Observatory).	11 32	−84.5	45.1	−13.0		216	
		−61.0	68.6	−4.0	31		
		−55.5	74.1	+8.0		33	
		−48.5	81.1	−5.0	123		
		−44.0	85.6	−12.0		463	
		−17.0	112.6	−9.5		108	
		−7.5	122.1	+5.5		28	
		+0.5	130.1	−11.0	3		
		+28.5	158.1	+7.5		139	
		+77.5	207.1	−10.0		62	1,206
Feb. 9 (Yerkes)	11 27	−69.7	46.8	−12.3		100	
		−35.7	80.8	−4.8		100	
		−34.9	81.6	−11.5		200	
		−24.0	92.5	−9.5		350	
		−9.0	107.5	−8.7		25	
		−1.3	115.2	−9.0		50	
		+44.7	161.2	+7.7		150	975
Feb. 10 (Naval Observatory).	11 47	−57.0	46.1	−13.5		185	
		−36.0	67.1	−18.0		62	
		−34.0	69.1	−5.0		108	
		−22.0	81.1	−5.0	108		
		−16.5	86.6	−10.5		478	
		+8.0	111.1	−9.0		123	
		+17.5	120.6	+5.0		22	
		+26.0	129.1	−13.0		9	
		+56.0	159.1	+7.5	77		1,172
Feb. 11 (Naval Observatory).	11 52	−42.5	47.4	−13.0		139	
		−20.0	69.9	−5.0		108	
		−8.5	81.4	−5.0	108		
		−2.0	87.9	−10.0		463	
		+23.0	112.9	−9.5		46	
		+70.0	159.9	+7.5	62		926
Feb. 12 (Naval Observatory).	11 48	−49.5	27.3	−5.5	12		
		−29.5	47.3	−12.5		139	
		−6.5	70.3	−17.0	3		
		−6.0	70.8	−5.5		77	
		+4.5	81.3	−5.0	93		
		+11.0	87.8	−10.5		417	
		+39.5	116.3	−9.0	31		772
Feb. 13 (Mount Wilson)	18 30	−14.0	46.0	−13.0		92	
		+11.0	71.0	−6.0		183	
		+21.0	81.0	−5.0		62	
		+28.0	88.0	−11.0		763	
		+62.0	122.0	−12.0		64	1,164
Feb. 14 (Naval Observatory).	12 5	−3.5	46.8	−12.5		62	
		+23.5	73.8	−6.0		340	
		+38.5	88.8	−10.5		509	
		+74.5	124.8	−11.0		216	1,127
Feb. 15 (Naval Observatory).	11 47	+10.0	47.3	−13.0	12		
		+38.0	75.3	−5.5		247	
		+52.0	89.3	−10.5		463	
		+84.5	121.8	−11.0		154	876
Feb. 16 (Harvard)	12 57	−63.5	320.0	+4.0	34		
		+24.5	48.0	−13.0	17		
		+52.5	76.0	−4.5		299	
		+65.0	88.5	−9.0		796	1,146
Feb. 17 (Naval Observatory.	11 42	−50.5	320.5	+6.0	62		
		0.0	11.0	−10.5	6		
		+36.5	47.5	−13.5	6		
		+57.5	68.5	+7.5		46	
		+65.0	76.0	−11.5		31	
		+66.5	77.5	−5.0	130		
		+77.5	88.5	−10.0		355	645

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longitude	Latitude	Spot	Group	
1929	h. m.	°	°	°			
Feb. 18 (Naval Observatory).	11 37	−64.5	293.4	−17.0		46	
		−38.5	319.4	+6.0		93	
		+42.5	40.4	+5.5		68	
		+50.0	47.9	−13.5	3		
		+81.0	78.9	−5.0	123		333
Feb. 19 (Naval Observatory).	11 54	−51.0	293.6	−16.5		62	
		−24.0	320.6	+6.5		77	
		+43.5	28.1	−5.0	9		
		+57.0	41.6	+6.5		77	225
Feb. 20 (Naval Observatory).	11 44	−65.5	266.0	−7.0	15		
		−38.5	293.0	−17.5		108	
		−9.5	322.0	+6.0		93	
		+56.5	28.0	−5.0	6		
		+73.0	44.5	+6.0		293	515
Feb. 21 (Naval Observatory).	11 38	−84.0	234.4	+7.0		231	
		−72.5	245.9	−14.5	77		
		−52.0	266.4	−7.0	15		
		−25.5	292.9	−17.0		62	
		+4.0	322.4	+6.0		123	
		+84.0	42.4	+6.5	154		662
Feb. 22 (Naval Observatory).	11 21	−69.5	235.9	+7.5		231	
		−59.0	246.4	−14.5	46		
		−38.0	267.4	−7.0	12		
		−15.0	290.4	−17.0		46	
		+17.5	322.9	+5.5		108	443
Feb. 23 (Naval Observatory).	11 38	−77.5	214.5	−8.5		201	
		−55.5	236.5	+8.0		216	
		−45.5	246.5	−14.5	46		
		−1.0	291.0	−17.0		31	
		+11.0	303.0	−15.0		9	
		+19.0	311.0	+8.5		19	
		+31.5	323.5	+6.0		108	630
Feb. 24 (Naval Observatory).	11 40	−65.0	213.9	−8.5		216	
		−42.5	236.4	+7.5		201	
		−32.5	246.4	−14.5	62		
		+13.5	292.4	−17.0		31	
		+24.5	303.4	−15.0		9	
		+44.5	323.4	+5.5		93	612
Feb. 25 (Naval Observatory).	12 32	−49.5	215.7	−9.0		185	
		−28.0	237.2	+7.5		170	
		−18.5	246.7	−15.0	31		
		+30.0	295.2	−17.0		62	
		+59.5	324.7	+7.5	22		470
Feb. 26 (Mount Wilson)	18 00	−31.0	218.0	−8.0	102		
		−10.0	239.0	+6.0		94	
		−3.0	246.0	−15.0	32		
		+42.0	291.0	−18.0		46	
		+51.0	300.0	−17.0		14	288
Feb. 27 (Naval Observatory).	15 8	−19.5	217.9	−8.5		123	
		+1.0	238.4	+7.0		108	
		+8.5	245.9	−15.0	25		
		+55.0	292.4	−16.0		108	
		+69.0	306.4	−15.5	31		395
Feb. 28 (Mount Wilson)	16 30	−13.0	210.5	−9.0	4		
		−5.0	218.5	−9.0		77	
		+16.0	239.5	+8.0		18	
		+23.0	246.5	−15.0		11	
		+70.0	293.5	−17.0		31	141
Mean daily area for February							634

PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR FEBRUARY, 1929

[Data furnished through the courtesy of Prof. W. Brunner, University of Zurich, Switzerland]

February, 1929	Relative numbers	February, 1929	Relative numbers	February, 1929	Relative numbers
1	34	11	(1)	21	[2] 58
2	38	12	[2] 83	22	58
3	32	13	70	23	57
4	44	14		24	65
5	46	15	68	25	60
6	[2] 74	16	51	26	
7		17	56	27	[2] 69
8	91	18	54	28	52
9	[2] 117	19	[3] W32		
10	[1] 121	20	56		

Mean, 24 days: 61.9.

[1] Passage of a large group through the central meridian.
[2] Passage of an average-sized group through the central meridian.
[3] New formation of a larger or average-sized center of activity; E, on the eastern part of the sun's disk; W, on the western part.

AEROLOGICAL OBSERVATIONS

By L. T. SAMUELS

Negative temperature departures, many of unusually large magnitude, occurred at all stations and levels. (See Table 1.) At Ellendale and Royal Center, the two northernmost stations, the departures continued large to the highest levels.

Free-air relative humidities, as might be expected with subnormal mean temperatures, averaged mostly above normal, especially at Ellendale and Royal Center and the vapor pressures practically all below normal.

It is surprising, in view of the low temperatures, to note in Table 2 that in many cases the free-air resultant wind direction for the month contained a greater south component than normal. This is particularly pronounced at Broken Arrow, Due West, and Royal Center. The resultant velocities were appreciably less than normal from the surface to 2,500 meters at all stations, except Royal Center and Washington where they were slightly in excess of the normal.

The following is taken from the report of the official in charge, Broken Arrow:

A fully developed thunderstorm passed over Tulsa and Broken Arrow between 1:30 a. m. and 2:30 a. m. on the 19th. Precipitation evidently formed at a considerable height near the top of a marked inversion shown on the kite records of the 18th and 19th. The total precipitation was not great, 0.06 inch. Part of it was hail, about the size of peas; part of it sleet, hard particles of various sizes, and there may have been some water droplets. However, there was no evidence of glaze the following morning. The thunderstorm passage was followed by light snowfall, with light flurries until 12:20 p. m.

Conditions favorable for strong convection at altitudes above 2,000 meters are strikingly shown by these kite records. Temperatures at Broken Arrow on the 19th rose with increasing altitude from −11° C. at the ground to slightly above freezing at 2,200 meters. The temperature fell at the rate of 0.4° C. per 100 meters for the next 500 meters, where the flight ended. It is probable that with further increase in altitude a superadiabatic lapse rate prevailed in view of the fact that a solid layer of A Cu clouds was observed through a break in the St clouds at 11:11 a. m.

This condition was the accompaniment of a strong triangular-shaped anticyclone having its center over Sioux City, Iowa, and straight isobars along its front extending in a NE.-SW. direction. Winds at Broken Arrow at the time were N. and NNE. from the ground to 1,000 meters, above which they gradually backed to WSW. at the maximum altitude (2,664 meters). Sleet was reported at several stations along the front of this HIGH on the same morning. On the preceding morning (18th) when the front of the HIGH had just reached the Broken Arrow region, NNE. surface winds were overrun by southerly winds from 1 to 3 km.

It is significant to note that ice formed on the kite wire and meteorograph on the 18th when the temperatures within the St cloud layer ranged from 3° C. to −8° C., whereas no ice formed on the 19th when the temperatures within the clouds were all below −8° C.

Conditions favorable for the formation of ice on the kite wire occurred at Groesbeck on the 8th when surface winds from the NNE. incident to an oncoming HIGH veered to ESE. at 1,350 meters, the maximum altitude. A strong temperature inversion prevailed from 500 meters to the maximum altitude with temperatures ranging from −6.4° C. to 8.6° C. The air was saturated from the ground to the highest level and the kite wire was heavily coated with ice when it was reeled in. A fine mist changed to heavy sleet when the flight ended.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during February, 1929*

Altitude m. s. l.	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)		Washington, D. C.[1] (7 meters)	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
	TEMPERATURE (° C.)											
Meters												
Surface	−2.9	−7.8	5.1	−3.0	−15.7	−6.0	3.2	−6.6	−6.0	−4.5	−0.8	−3.2
250	−3.0	−7.8	5.0	−2.9			2.9	−6.5	−6.2	−4.5	−1.9	−3.2
500	−3.8	−7.5	4.9	−2.0	−15.6	−5.9	2.7	−5.9	−7.5	−4.0	−2.6	−3.2
750	−3.7	−6.7	4.3	−1.9	−14.2	−4.9	3.3	−5.0	−8.0	−3.8	−3.1	−2.7
1,000	−2.8	−5.6	3.3	−2.1	−13.6	−5.0	4.6	−3.6	−8.6	−4.1	−3.8	−2.2
1,250	−2.4	−4.9	2.3	−2.2	−13.7	−5.6	4.8	−2.9	−8.9	−4.0	−4.4	−1.8
1,500	−2.5	−4.4	1.2	−2.4	−13.6	−5.6	4.2	−2.7	−9.4	−4.0	−4.9	−1.6
2,000	−3.3	−3.6	−0.4	−2.1	−14.6	−5.2	2.7	−2.2	−11.0	−4.2	−6.1	−1.8
2,500	−5.4	−3.4	−2.3	−1.6	−17.1	−5.4	0.3	−2.2	−13.0	−4.3	−8.1	−1.9
3,000	−7.4	−2.8	−3.9	−0.8	−19.5	−5.1	−1.6	−1.7	−15.1	−3.9	−10.8	−1.8
3,500	−9.8	−2.7			−21.9	−4.8	−3.5	−1.2	−18.1	−4.1		
4,000	−11.7	−1.9			−24.5	−4.8	−5.1	−0.4	−21.9	−4.7		
4,500					−28.7	−6.1	−8.1	−0.7	−26.0	−5.2		
	RELATIVE HUMIDITY (%)											
Surface	78	+9	73	+4	83	+2	85	+11	83	+5	70	0
250	78	+9	72	+3			81	+9	83	+5	68	0
500	76	+10	65	0	83	+3	71	+3	84	+6	64	−1
750	71	+9	59	−3	80	+6	63	0	80	+5	60	−4
1,000	63	+6	60	−1	78	+9	55	−2	77	+7	58	−6
1,250	60	+6	55	−5	77	+12	53	−1	72	+7	56	−7
1,500	59	+7	53	−5	75	+14	51	+1	68	+7	54	−7
2,000	49	+2	50	−5	70	+12	48	+3	61	+6	48	−7
2,500	45	0	42	−11	74	+16	49	+6	62	+9	43	−8
3,000	42	−2	37	−13	76	+19	45	+4	62	+8	37	−13
3,500	35	−8			76	+21	44	+5	64	+10		
4,000	33	−10			76	+22	42	+6	67	+12		
4,500					71	+18	42	+10	85	+23		
	VAPOR PRESSURE (mb.)											
Surface	3.98	−2.26	7.23	−0.77	1.58	−1.01	7.10	−2.39	3.47	−1.05	4.14	−1.11
250	3.95	−2.24	7.14	−0.74			6.66	−2.40	3.43	−1.02	3.74	−0.96
500	3.62	−1.85	6.57	−0.50	1.59	−0.95	5.84	−2.31	3.08	−0.85	3.30	−0.96
750	3.44	−1.40	5.93	−0.63	1.72	−0.67	5.34	−2.06	2.77	−0.81	2.92	−0.96
1,000	3.19	−1.20	5.54	−0.60	1.70	−0.61	4.99	−1.62	2.54	−0.69	2.70	−0.88
1,250	3.12	−0.86	4.56	−1.03	1.61	−0.61	4.62	−1.30	2.29	−0.57	2.46	−0.80
1,500	3.01	−0.56	3.79	−1.21	1.53	−0.54	4.28	−0.88	2.07	−0.49	2.28	−0.70
2,000	2.25	−0.56	2.64	−1.30	1.32	−0.41	3.68	−0.34	1.61	−0.42	1.87	−0.55
2,500	1.81	−0.50	1.75	−1.34	1.10	−0.32	3.30	+0.05	1.34	−0.34	1.41	−0.48
3,000	1.51	−0.37	1.52	−0.85	0.92	−0.19	2.77	+0.08	1.10	−0.26	0.86	−0.57
3,500	1.23	−0.34			0.76	−0.09	2.64	+0.42	0.88	−0.19		
4,000	1.09	−0.21			0.65	−0.02	2.58	+0.81	0.78	−0.07		
4,500					0.45	−0.09	2.54	+1.20	0.80	−0.01		

[1] Naval Air Station.

TABLE 2.—*Free-air resultant winds (m. p. s.) during February, 1929*

Altitude m. s. l.	Broken Arrow, Okla. (233 meters)				Due West, S. C. (217 meters)				Ellendale, N. Dak. (444 meters)				Groesbeck, Tex. (141 meters)				Royal Center, Ind. (225 meters)				Washington, D. C. (34 meters)			
	Mean		Normal		Mean		Normal		Mean		Normal		Mean		Normal		Mean		Normal		Mean		Normal	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
Meters	°		°		°		°		°		°		°		°		°		°		°		°	
Surface	N.27 W.	0.8	N.60 W.	0.5	S.72 E.	0.7	S.80 W.	1.3	N.40 W.	2.2	N.48 W.	3.2	N.27 E.	2.2	N.73 W.	0.5	S.52 W.	1.9	S.80 W.	1.9	N.37 W.	1.2	N.48 W.	1.5
250	N.35 W.	0.6	N.63 W.	0.4	S.66 E.	0.8	S.80 W.	1.4					N.41 E.	2.4	S.76 W.	0.6	S.45 W.	2.3	S.78 W.	2.2	N.41 W.	4.2	N.61 W.	3.4
500	S.38 W.	0.5	S.56 W.	0.8	S. 1 E.	2.1	S.78 W.	3.1	N.47 W.	2.0	N.52 W.	3.4	N.83 E.	1.9	S.45 W.	1.0	S.63 W.	4.2	S.68 W.	4.0	N.51 W.	6.4	N.66 W.	5.3
750	S.33 W.	0.8	S.58 W.	1.9	S.34 W.	2.9	S.76 W.	4.2	N.56 W.	2.6	N.57 W.	4.5	S.61 E.	0.7	S.54 W.	2.3	S.73 W.	5.4	S.71 W.	5.7	N.57 W.	7.8	N.66 W.	6.8
1,000	S.28 W.	1.6	S.67 W.	2.8	S.54 W.	3.8	S.83 W.	5.6	N.62 W.	3.6	N.56 W.	5.3	S.21 W.	1.8	S.63 W.	3.5	S.77 W.	7.8	S.80 W.	7.0	N.54 W.	8.9	N.60 W.	8.1
1,250	S.47 W.	2.6	S.85 W.	3.8	S.65 W.	6.0	S.84 W.	7.3	N.62 W.	4.6	N.57 W.	6.3	S.47 W.	2.7	S.73 W.	4.5	S.77 W.	8.9	S.85 W.	8.0				
1,500	S.65 W.	4.2	S.89 W.	4.7	S.73 W.	7.9	S.87 W.	9.4	N.65 W.	4.6	N.60 W.	7.2	S.81 W.	3.2	S.78 W.	5.8	S.83 W.	10.5	W.	9.3	N.60 W.	8.9	N.68 W.	11.6
2,000	S.74 W.	6.1	N.86 W.	6.6	S.79 W.	9.0	S.87 W.	12.4	N.62 W.	7.1	N.62 W.	9.4	S.77 W.	5.5	S.86 W.	7.4	S.80 W.	12.3	N.86 W.	11.4	N.69 W.	10.9	N.70 W.	11.9
2,500	S.83 W.	9.3	N.85 W.	7.8	S.77 W.	10.8	W.	14.4	N.64 W.	10.4	N.63 W.	11.4	S.88 W.	7.1	S.87 W.	8.8	S.84 W.	13.7	N.85 W.	13.0	N.85 W.	11.8	N.74 W.	15.7
3,000	S.85 W.	9.5	N.83 W.	9.7	W.	18.3	S.87 W.	16.2	N.70 W.	12.8	N.65 W.	12.7	N.89 W.	12.0	S.86 W.	10.8	S.89 W.	15.5	N.88 W.	13.9	N.80 W.	13.0	N.76 W.	15.0
3,500	S.76 W.	11.7	N.73 W.	10.9					N.76 W.	13.7	N.68 W.	13.0	N.78 W.	15.3	W.	11.8	S.86 W.	16.4	N.88 W.	15.8	N.87 W.	16.2	N.76 W.	16.9
4,000	N.87 W.	12.0	N.74 W.	11.0					N.53 W.	12.4	N.67 W.	13.8	N.80 W.	15.6	N.88 W.	11.9	S.68 W.	19.0	S.86 W.	15.3	N.85 W.	19.0	N.78 W.	18.2
4,500									N.68 W.	16.9	N.68 W.	15.4	N.68 W.	15.0	N.84 W.	12.7	S.68 W.	21.0	S.76 W.	19.4	N.78 W.	21.6	N.76 W.	18.0
5,000									N.68 W.	18.0	N.85 W.	17.0	W.	17.0	N.70 W.	10.5					W.	20.0	N.80 W.	16.2

WEATHER IN THE UNITED STATES

THE WEATHER ELEMENTS

By P. C. DAY

GENERAL CONDITIONS

Like the first month of the year, February, 1929, continued colder than normal over most parts of the country and decidely so in the northern districts from the Great Lakes westward, particularly in the far Northwest, where in some localities the month, as a whole, was the coldest of record for February, and over many other sections it stands as the second coldest February in more than 50 years.

It was also a notable month for the depth of the accumulated snow and the length of time it remained on ground over portions of the upper Mississippi Valley and near-by areas. The month was also among the wettest of record for February in a few of the Southeastern States and the driest in the far Northwest.

PRESSURE AND WINDS

The atmospheric pressure showed no unusual conditions, save the anticyclone persisted rather steadily over the Plateau area during the early part of the month and cyclones were rather frequent during the latter part over the eastern and southeastern sections.

Cold weather prevailed at the beginning over most central districts and was advancing eastward with sharp changes to colder in the Gulf States and lower Ohio Valley and a change to warmer was overspreading the northern Rocky Mountains and Plains States. Within a few days the weather became somewhat settled and steady cold existed in most northern districts.

By the morning of the 6th a cyclone had moved from the central Rocky Mountains to the middle Gulf coast and general rains had overspread the Gulf and South Atlantic States, and local snows, mostly light, had occurred over a wide area from the middle Rocky Mountains northeastward to the upper Lakes. By the morning of the 7th the eastern precipitation area had moved to the southern New England coast and important rains had occurred over the near-by areas while light snow continued in the western areas, the precipitation extending during the following day into the central and southern parts, the snow becoming very general in the Lake region and changing to sleet in portions of the southern Plains. This precipitation area extended during the 9th and 10th into most eastern districts and was followed by mostly clear to fair weather for several days.

During the 15th to 17th considerable rain occurred over the Gulf and South Atlantic States and light snows occurred at the same time over a considerable area along the northern border from the Rocky Mountains to the Great Lakes, extending southward to the Great Plains and Ohio Valley during the following day or two, and finally changing to rain over most districts from Texas and the Gulf States northeastward at the beginning of the third decade, the precipitation becoming heavy on the 21st and 22d and changing to snow or sleet along the middle Atlantic coast and to the northward.

During the early part of the month local precipitation prevailed in the middle and southern portions of the more western districts, but in the far Northwest there was little or no important precipitation until after the end of the second decade, and even after that time the precipitation in this region was light and generally local.

By the morning of the 24th a cyclone had developed over the southern Rocky Mountains and precipitation had occurred during the preceding 24 hours over the North Pacific coast and southeastward to Wyoming and Colorado. On the 25th the precipitation area had extended to the lower Mississippi Valley and by the next morning the center of the storm area had moved to Wisconsin and rain had overspread much of the country from the Mississippi Valley eastward, the falls becoming heavy in portions of the lower Mississippi and Ohio Valleys. During the 27th this rain area passed off the Atlantic coast, and another had advanced to the west Gulf coast, which during the last day moved northeast to the Carolinas, attended by heavy rains along the South Atlantic coast and by local snows over the northern portions of the precipitation area. At the same time other areas of low pressure had moved to the southern Plains and southern Rocky Mountain regions and precipitation was threatening over the entire Gulf region at the end of the month.

The averages of pressure and departures from normal and the changes in pressure from the preceding month are shown on Chart VI, and on the insets to Charts II and III, respectively, and the more important facts concerning the high winds of the month appear in the table at the end of this section.

TEMPERATURE

As stated previously, February was a decidedly cold month and this condition applied to all parts save a few of the more Northeastern States and over the Florida Peninsula and portions of near-by Georgia.

The first week was cold in all parts save the extreme Northeast and over the Southwest. The week was particularly cold over the central valleys and along the northern boundary from the Dakotas westward to Washington and Oregon, where the negative departures ranged from 10° to nearly 30°.

The second week was generally the coldest of the month, particularly over the region from the Rocky Mountains westward and from the middle Plains eastward to the Atlantic coast, save in portions of the Southeastern States, where the first day of the month was the coldest. This week was moderately warm over the Northeastern States and over the Florida Peninsula. In the interior and northern sections from the upper Mississippi and Ohio Valleys westward to the Plateau region the weekly means ranged from 10° to 20° and locally to 30° below normal, and minimum temperatures from 40° to 60° below zero were reported from exposed points in the central and northern mountain regions of the west.

The third week continued cold over nearly all parts save that it continued moderately warm over the Northeastern States and the Florida Peninsula and it was warmer than normal along the Rio Grande. The week was not so cold as the previous weeks in the Missouri Valley and far Northwest, though the lowest temperatures of the month were observed at the end over the northern section from the Dakotas and Nebraska eastward to Lake Superior.

From the 19th to the end of the month the weather continued cold over the greater part of the country and the lowest temperatures of the month were reported in the Northern States from the Great Lakes eastward. This period continued warmer than normal over the Florida Peninsula and it was slightly warmer than normal generally over the Pacific Coast States.

The month, as a whole, was the coldest of record in portions of the far Northwest, and for a period covering about a month from January 19 to February 18, inclusive, 31 days, the departure for the period averaged slightly more than 17° below the normal, a record unsurpassed in any similar winter period in the history of meteorological observations in that part of the country.

PRECIPITATION

There were but 10 States in which the average precipitation differed by as much as an inch from the normal for February. In the three Pacific States the deficiencies were large, notably in Oregon, which received but little more than a fourth of the normal quantity, on the average. The interior States as far as the Rocky Mountain Divide mainly received less than normal, save that eastern Utah and the western portions of Colorado and Wyoming mainly received somewhat more than normal.

Central and southern Texas and the Florida Peninsula recorded considerably less precipitation than normal, while farther north most of the central valleys district and practically every part of the Lake region reported moderate shortages, likewise almost every other district along the Canadian border, save that Washington had a marked deficiency, as already noted.

More precipitation than normal was received in the middle Missouri Valley, the southern two-thirds of New England and the eastern part of the Middle Atlantic States, and especially from southern Louisiana northeastward to southeastern Virginia. Within this latter belt the excess was especially marked over southern Alabama, central and northern Georgia, and the Carolinas. Some stations of long record in this area found all previous February totals exceeded. The greatest amount at any single station, as far as reported, was 16.75 inches, at River Falls, Ala.

SNOWFALL

The snowfall was mainly light in quantity in the Pacific States, and in the mountainous portions of the Southern States, save that northwestern Texas reported considerable amounts for the region, chiefly during the opening decade, and northern Georgia reported fairly large amounts on the 5th. In most other portions of the country the snowfall was greater than the normal.

In the upper Mississippi Valley, where the January snowfall had been remarkably heavy and had left the ground covered to unusual depths, the February new snowfall was not especially large, as a rule, but it was dry and drifted to an unusual extent, so that traffic on the main-traveled roads was greatly hindered. Generally the north-central portion of the country remained deeply covered till near the end of the month. At Charles City, Iowa, it was noted that the depth of snow on February 26 was the greatest ever recorded there, while in much of Kansas and Oklahoma the ground was snow covered many more days than had been the case before for several years.

At the end of February the snow pack in the elevated portions of the Western States was mainly greater than normal, especially in the Rocky Mountain States and the central part of the Plateau region. In the Pacific States the accumulated snow was mainly less than normal and the prospect there for a good water supply was not favorable.

RELATIVE HUMIDITY

The percentages of relative humidity were nearly everywhere above normal practically the only exception being at points in the Pacific Coast States, where deficiencies were quite marked locally which might be expected from the general absence of important precipitation during the month and in fact for several preceding months.

SEVERE LOCAL STORMS, FEBRUARY, 1929

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Charlotte to Raleigh, N. C.	20-21					Glaze	Telegraph, telephone, and trees damaged	Official, U. S. Weather Bureau. Dallas Morning News (Tex.).
Dallas County, Tex.	25	4:05 a. m.	60	2	$200,000	Tornado and hail.	Many homes and small buildings demolished; 3 persons injured; path 4 miles.	Do.
Cooper, Tex.	25	6:30 a. m.	60	2	40,000	do	A number of buildings destroyed over path ½ mile long; 9 persons injured.	Do.
Mesquite, Tex. (3 miles east of).	25	A. m.				Probably tornado.	Farm property damaged; 1 person injured	Do.
Darling, Miss. (3 miles west of).	25	P. m.		2		do	Considerable property damage	Official, U. S. Weather Bureau.
Duncan, Miss., and vicinity.	25	P. m.		17		do	The town of Duncan practically demolished; 40 persons injured.	Do.
Gibson, Carroll, Montgomery, Wilson Counties, Tenn.	25-26				25,000	High winds	Houses unroofed or blown down; many trees and telephone poles broken off; barns and other buildings damaged.	Do.

RIVERS AND FLOODS

By R. E. SPENCER

Reports received too late for inclusion in the January issue of this REVIEW indicate that the losses in the Tombigbee River flood of that month amounted to $4,100 instead of $700, as printed, and that a saving of $31,000 was effected through Weather Bureau flood warnings.

During February floods were numerous; but, except in the case of those of the interior rivers of Ohio, no very destructive overflow occurred.

Atlantic drainage.—In Connecticut heavy rains, beginning on the evening of the 6th, caused sharp rises in several small streams, resulting in considerable inconvenience, some flooding of streets and sewers, and three deaths by drowning. Crop losses in the Peedee rise following the 19th approximated $10,000, while savings to the amount of $100,000 were effected through flood warnings to lumber interests and cattle raisers. Other rises in the Atlantic drainage, practically none of which assumed proportions of real importance until March, will be discussed in the REVIEW for that month.

East Gulf drainage.—As was the case in most of the floods of the South Atlantic drainage, the east Gulf floods, rising from the rains of the latter half—and especially the last two days—of February, continued with increasing proportions into March, and will be discussed in the REVIEW for that month.

Great Lakes drainage.—These moderate rises, the result of a period of light rains and thaw following the 23d, were without consequence.

Ohio drainage.—Except in the interior rivers of the State of Ohio, the floods of the Ohio River drainage were in the main of minor importance. In the Ohio River itself, owing to the presence of ice, navigation was partly suspended between the 2d and the 5th and again from the 6th to the 10th. At Pittsburgh, $5,000 damage was done by the flooding of a warehouse. In and below the Parkersburg district some inconvenience was experienced and minor overflows of lowlands and roads occurred, but losses were negligible. It is noteworthy, however, that possibly serious damage to the Ohio River dams was prevented only by the greatest care in operation during the movement of the ice, full information of which was made available to the United States Engineer Corps by the Weather Bureau.

The floods of the interior rivers of Ohio, which were by far the most damaging of the month, resulted from an unusual combination of snow, frozen ground, ice, high temperature, and heavy rain. The official in charge of the Weather Bureau office at Columbus, Ohio, describes this condition as follows:

> The month began with a snow covering, varying in depth from 1 to 3 inches, quite general over the State; and during the first three weeks this covering was increased by subsequent falls considerably in excess of the total monthly normal amount. Moreover, persistent subnormal temperature during this period allowed but little melting of the snow, so that on the 23d there remained a covering of from 1 to 8 inches over the State. The rivers were also frozen over with several inches of ice. On the 24th a warm wave of marked intensity overspread the State, culminating in numerous thunder storms and warm heavy rains which, beginning on the afternoon of the 25th, became heavy during the night of the 25th-26th. Owing to the frozen condition of the ground this precipitation, greatly augmented by the melting snow cover, quickly found its way into the streams, so that in 24 hours time practically all the streams in the State were changed from dead frozen rivers near the low water mark to near bankful stage, and some even to flood stage.

Warnings were of course issued as early as possible and were given distribution by every means available; but in spite of them the rise, naturally sudden and inevitably destructive, did damage reported or conservatively estimated at $1,938,775. Of this total, $1,812,800 was in tangible property—bridges, buildings, factories, highways, municipal plants, etc.—$25,000 to wheat fields and lowlands, and $100,000 to suspension of business. Of the savings effected through flood warnings nothing definite could be determined except that the figure would exceed $2,000,000.

From the character of the damage it is evident that the greatest destruction was done in towns and cities, details as to some of which—i.e., the Miami River drainage basin—are not yet available, and will doubtless considerably increase the total figure of losses for the State. The Miama flood will be discussed in the REVIEW for March.

Except for the destruction of a $10,000 bridge in Lee County, Ky., on the Kentucky River, and the temporary suspension of ferry service at several points on the Wabash other Ohio tributary rises were without material consequence. The explanation of this in the case of the Wabash flood, which rose from the same causes as those of the interior Ohio rivers and involved practically the entire Wabash system, is that there had been no time for reconstruction since the earlier and greater Wabash flood of January.

Miscellaneous.—Of the flood in the Illinois River of Illinois, the official in charge of the Weather Bureau office at St. Louis, Mo., reports in part as follows:

> The alluvial Illinois was abnormally high throughout the winter. A rise in January was subsiding when February opened, and flood

stages were general from Henry, Ill., southward. Mild weather during the latter part of February caused the ice to move, releasing a considerable amount of water, and rising stages were general; below Morris they prevailed into March. The damage caused by the rise was not great; it was confined largely to the flooding of some roads.

This flood will be mentioned also in the March report.

The Grand River flood of Missouri, most of whose damage was done after the close of February, will be discussed in the March REVIEW.

The remaining floods of February were in general of little importance.

[All dates in February except as otherwise specified]

River and station	Flood stage	Above flood stages—dates From—	Above flood stages—dates To—	Crest Stage	Crest Date
ATLANTIC DRAINAGE	Feet			Feet	
Schuylkill: Reading, Pa	10	26	26	10.8	26
Roanoke: Weldon, N. C	30	28	[1]	32.8	28
Neuse:					
Neuse, N. C	15	28	[1]	17.1	28
Smithfield, N. C	14	28	[1]	16.3	28
Cape Fear:					
Fayetteville, N. C	35	28	[1]	39.6	28
Elizabethtown, N. C	22	19	19	22.1	19
		28	[1]	25.1	28
Haw: Moncure, N. C	22	28	[1]	25.0	28
Peedee:					
Cheraw, S. C	27	28	[1]	32.2	28
Mars Bluff, S. C	17	19	[1]	18.9	26
Santee:					
Rimini, S. C	12	10	[1]	18.6	21
Ferguson, S. C	12	10	[1]	13.7	22
Catawba: Catawba, S. C	12	28	[1]	14.0	28
Congaree: Columbia, S. C	15	28	[1]	20.8	28
Broad: Blair, S. C	15	28	[1]	24.0	28
Saluda:					
Pelzer, S. C	7	28	[1]	9.6	28
Chappels, S. C	14	22	23	15.1	23
		28	[1]	20.3	28
Savannah: Augusta, Ga	32	28	[1]	36.7	28
Broad: Carlton, Ga	11	21	21	11.0	21
		27	[1]	17.0	28
Altamaha:					
Charlotte, Ga	15	20	[1]	18.6	25
Everett City, Ga	10	22	[1]	11.8	28
Oconee: Milledgeville, Ga	22	27	[1]	35.7	28
Ocmulgee:					
Macon, Ga	18	27	[1]	25.8	28
Abbeville, Ga	11	19	[1]	13.3	23
EAST GULF DRAINAGE					
Apalachicola: Blountstown, Fla	20	25	[1]	20.0	25, 26, 28
Flint: Albany, Ga	20	23	24	20.6	24
Chattahoochee:					
Goat Rock, Ga	10	27	[1]	11.2	27
Eufaula, Ala	40	28	[1]	47.2	28
Alaga, Ala	30	28	[1]	34.2	28
Choctawhatchee:					
Newton, Ala	24	28	[1]	25.2	28
Geneva, Ala	12	16	[1]	21.9	28
Caryville, Fla	12	19	20	12.1	19
		24	27	12.3	25
Conecuh: Brewton, Ala	13	17	[1]	16.8	28
Alabama:					
Montgomery, Ala	35	28	[1]	42.3	Mar. 1
Selma, Ala	35	28	[1]	45.7	Mar. 3
Coosa: Lock No. 4, Lincoln, Ala	17	28	[1]	17.1	28
Tombigbee: Lock No. 4, Demopolis, Ala	39	[2]	1	39.5	Jan. 31
		28	[1]	41.4	28
Black Warrior: Lock No. 10, Tuscaloosa, Ala	46	28	[1]	47.8	28
Pearl: Columbia, Miss	18	17	17	18.0	17
Bogue Chitto: Franklinton, La	16	17	17	17.0	17
West Pearl: Pearl River, La	13	18	[1]	16.6	19
GREAT LAKES DRAINAGE					
Maumee:					
Fort Wayne, Ind	15	27	28	15.4	27
Napoleon, Ohio	10	27	28	11.4	27
St. Joseph: Montpelier, Ohio	10	27	28	12.5	28
Sandusky:					
Upper Sandusky, Ohio	13	27	27	13.8	27
Tiffin, Ohio	7	27	28	8.0	28
Fremont, Ohio	11	27	27	12.6	27
Grand:					
Eaton Rapids, Mich	5	27	28	5.5	28
Grand Ledge, Mich	7	27	28	8.0	28
Red Cedar: Williamston, Mich	6	27	28	7.0	28
MISSISSIPPI DRAINAGE					
Allegheny:					
Lock No. 5, Freeport, Pa	24	27	27	28.7	27
Lock No. 4, Natrona, Pa	24	27	27	26.4	27
Ohio:					
Pittsburgh, Pa	25	27	27	25.3	27
Dam No. 25, near Point Pleasant, W. Va	40	28	[1]	40.4	28
Point Pleasant, W. Va	40	28	[1]	44.2	Mar. 2
Evansville, Ind	35	[2]	2	38.5	Jan. 29

[1] Continued at end of month. [2] Continued from last month.

[All dates in February except as otherwise specified]

River and station	Flood stage	Above flood stages—dates From—	Above flood stages—dates To—	Crest Stage	Crest Date
ATLANTIC DRAINAGE	Feet			Feet	
Ohio:					
Dam No. 48, Cypress, Ind	35	[2]	1	37.2	Jan. 30
Shawneetown, Ill	35	[2]	4	40.3	Jan. 31
Beaver: Beaver Falls, Pa	11	27	27	11.5	27
Chenango: Sharon, Pa	9	27	28	10.1	27
Muskingum:					
Zanesville, Ohio	25	27	28	26.4	27
McConnelsville, Ohio	22	27	[1]	25.6	28
Tuscarawas:					
Dover, Ohio	9	27	27	10.0	27
Coshocton, Ohio	8	27	28	17.0	27
Walhonding: Walhonding, Ohio	8	26	28	16.5	26
Scioto:					
Larue, Ohio	11	26	28	14.4	27
Prospect, Ohio	10	26	[1]	14.1	28
Bellpoint, Ohio	9	26	27	11.7	26
Circleville, Ohio	10	27	[1]	18.4	27
Chillicothe, Ohio	16	27	[1]	26.5	28
Olentangy: Delaware, Ohio	9	26	27	14.2	26
Miami:					
Sidney, Ohio	12	26	27	13.4	26
Franklin, Ohio	16	26	27	16.1	27
Middletown, Ohio	15	26	[1]	19.0	27
Hamilton, Ohio	17	26	26	17.4	26
Mad: Springfield, Ohio	11	26	26	15.1	26
Stillwater: Pleasant Hill, Ohio	13	26	26	16.4	26
Whitewater: Brookville, Ind	20	26	26	25.4	26
Kentucky: Beattyville, Ky	30	27	27	33.8	27
Green:					
Munfordville, Ky	27	28	[1]	27.9	Mar. 1
Lock 6, Brownsville, Ky	30	27	[1]	32.6	28
Lock 4, Woodbury, Ky	33	26	[1]	41.3	Mar. 1
Lock 2, Rumsey, Ky	34	28	[1]	39.3	Mar. 7
Big Barren: Bowling Green, Ky	20	27	[1]	25.2	28
Wabash:					
Lafayette, Ind	13	27	[1]	14.3	28
Covington, Ind	16	28	[1]	17.7	Mar. 1
Vincennes, Ind	14	[2]	[3]	15.8	Jan. 28
Mount Carmel, Ill	16	[2]	4	23.0	Jan. 29; Jan. 30
White: Decker, Ind	18	[2]	4	23.5	Jan. 28; Jan. 30
White, East Fork:					
Seymour, Ind	10	27	28	14.3	27
Williams, Ind	10	[2]	[3]	14.7	Jan. 26
Shoals, Ind	20	[2]	1	26.4	Do.
White, West Fork:					
Anderson, Ind	12	27	27	12.5	27
Elliston, Ind	19	27	[1]	21.7	28
Edwardsport, Ind	15	[2]	[3]	19.0	Jan. 24
		27	[1]	17.8	Mar. 1; Mar. 2
French Broad: Asheville, N. C	4	28	28	4.4	28
Big Pigeon: Newport, Tenn	6	28	28	7.7	28
Holston, North Fork: Mendota, Va	8	27	28	8.7	28
Elk: Fayetteville, Tenn	14	27	28	14.7	27
Mississippi: New Madrid, Mo	34	2	4	34.3	3
Illinois:					
Morris, Ill	13	27	27	13.8	27
Peru, Ill	14	[2]	[1]	19.5	Jan. 24; Jan. 25
Henry, Ill	10	[2]	10	12.7	Jan. 28
		27	[1]	13.8	Mar. 6; Mar. 7
Peoria, Ill	18	[2]	5	19.6	Jan. 30
Havana, Ill	14	[2]	[1]	17.1	Mar. 6; Mar. 7
Beardstown, Ill	14	[2]	11	17.5	Jan. 29; Feb. 1
		27	[1]	17.9	Mar. 6; Mar. 8
Pearl, Ill	12	[2]	7	13.5	1
St. Francis: St. Francis, Ark	17	[2]	8	24.5	Jan. 30
		26	[1]	19.4	28
Missouri: Waverly, Mo	23	27	27	23.8	27
Grand, West Fork: Gallatin, Mo	20	26	[1]	25.3	28
Grand: Chillicothe, Mo	18	26	[1]	26.4	28
Grand, Thompsons Fork: Trenton, Mo	20	26	26	20.9	26
Arkansas: Yancopin, Ark	29	[2]	14	30.6	1
Petit Jean: Danville, Ark	20	26	[1]	23.0	27
White:					
Newport, Ark	26	[2]	[3]	29.0	Jan. 29
Georgetown, Ark	22	[2]	9	24.8	1, 2
De Valls Bluff, Ark	24	1	9	25.3	4
Black:					
Corning, Ark	11	[2]	10	14.1	Jan. 31
		26	[1]	13.0	Jan. 28
Black Rock, Ark	14	[2]	11	24.6	Jan. 26
		26	[1]	21.0	27
Cache: Patterson, Ark	9	[2]	11	9.7	1, 2
Sulphur:					
Ringo Crossing, Tex	20	27	[1]	24.5	28
Finley, Tex	24	[2]	2	26.7	Jan. 29
Ouachita:					
Arkadelphia, Ark	12	27	28	13.4	27
Camden, Ark	30	[2]	[3]	31.7	Jan. 30
WEST GULF DRAINAGE					
Trinity River:					
Dallas, Tex	25	26	27	32.8	27
Trinidad, Tex	28	[2]	[3]	29.8	Jan. 30

[1] Continued at end of month.
[2] Continued from last month.
[3] Below flood stage at 8 a. m. Feb. 1, 1929.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, FEBRUARY, 1929

By J. B. KINCER

General summary.—The extremely low temperatures that persisted over much of the country during the first decade made a generally unfavorable period for outside operations. Little farm work was accomplished in central and western sections and highway traffic was difficult in many places. The extensive snow cover made feeding necessary and widespread reports were received of suffering among livestock with considerable shrinkage. Heavy firing of citrus groves was necessary in California and tender vegetation suffered some injury in the west Gulf area. Low temperatures in other Gulf sections retarded growth and frequent rains prevented much field work, with spring preparations backward in many places.

While there was some improvement in the weather during the second decade in some of the western grazing areas, conditions continued generally unfavorable for livestock in most places, with persistent cold and much range land snow covered. The coldest weather of the season was experienced in some parts of the northern Great Plains. At the close of the period a light snow cover had been deposited over much of the winter wheat area, but in Central Northern States snowfall was mostly light, although sufficient in places to impede highway traffic. Cool, cloudy, wet weather delayed field operations in the South and retarded growth of winter crops, with spring preparations much behind the average season in many localities. In much of Florida and western Texas the weather was more favorable, while late reports indicated frost damage to crops in California.

During the last decade the weather, in general, remained unfavorable for seasonal farm operations, with unusually cold weather reported in the interior. Late in the period milder weather prevailed, with the snow cover largely removed from the Ohio Valley, but there was a deposit of heavy, wet snow over the upper Mississippi Valley and the western Lake region. The snow disappeared rapidly in the Middle Atlantic area, under the influence of warmer weather, but outside work was still delayed. Rains were again frequent in the South, with the soil too wet for plowing and other spring operations. Low temperatures favorably retarded fruit buds in the west Gulf area, but the mild weather in the Southeast caused considerable development, with some peaches beginning to open in the Fort Valley district of Georgia by the close of the month.

Small grains.—During the first decade the winter wheat belt experienced rather low temperatures, but they were preceded in the southwest by generous snows and the main area had a fairly good blanket. Although much ice remained in northern Illinois and Indiana and in much of Missouri, wheat was well protected generally. In the more northwestern States and Rocky Mountain sections winter wheat fields were amply covered, but the ground was bare in the Atlantic coast area.

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During the second decade a brief mild period caused some improvement in the ice conditions, and much snow was also removed in the central and southern portions of the belt. Low temperatures again overspread the region, but there was an additional light layer of snow in many sections. While fields were generally bare in Kansas, with plants frozen to the ground, there was apparently no serious or widespread harm; some heaving was reported in Kentucky. In the more northwestern States fields were still well covered; in the South winter cereals made slow growth.

During the last decade a severe cold wave overspread the central wheat belt, but fields were generally well protected by an ample snow cover. A reaction to milder later in the period cleared the snow from much of the wheat area, and toward the close of the month the ground was mostly bare east of the Mississippi River; at the same time there was a heavy fall in upper Mississippi Valley districts. The snow largely melted in Nebraska, but western Kansas was covered with from 1 to 5 inches. Wheat made but little growth in the Southwest, while in the far Northwest there was considerable melting of snow with many sections bare.

Miscellaneous crops.—Pastures remained in generally poor or dormant condition in southern sections during most of the month, except for some improvement toward the close. An ample snow covering prevailed in central-northern districts during the severe weather, but there were local complaints of unfavorable freezing and thawing in the Ohio Valley during the second decade. Heavy feeding was necessary in the northern Great Plains most of the month, with local livestock deterioration, but toward the close there was some moderation of the wintry conditions. There were continued reports from Wyoming of small losses or shrinkage and the range remained generally closed; this month made the third one of severe wintry weather and conditions were critical in some western parts of the State, with feed scarce in some parts. The last decade brought more seasonable weather to the central Rocky Mountain region and the Southwest, where considerable suffering among livestock was reported early in the month. Cold weather was rather detrimental to young lambs in Pacific Coast States. Feed was generally ample during the month in most sections, but toward the close it had become short in many localities, especially in Idaho and parts of Wyoming.

Except for some delay by cold weather, southern truck crops made satisfactory advance during the month and some potatoes were planted toward the close in the Southeast. Tobacco in beds was in good condition in the South and some work had been done in preparation of seed beds in northern sections. There was some injury to peach buds by the cold weather of the month, especially in Indiana, Illinois, and Missouri, but deciduous fruits were generally in satisfactory condition. Citrus fruits did well but there was some injury by frost to oranges and lemons in California during the second decade.

WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

Over the northern steamer lanes the weather during February would not be considered as unusually stormy for a winter month. In the region between the Bermudas and Azores, however, the number of days with gales was considerably above the normal, and vessels between the fortieth and fiftieth parallels encountered winds of hurricane force, as shown by reports in table.

The North Atlantic HIGH was unusually well developed during the first 15 days of the month, while from the 16th to the 28th low pressure was the rule over this area, and on only one day during the latter period was the barometric reading at Horta equal to, or above, the normal for the month. The Icelandic LOW was unusually inactive, as indicated by the abnormally high barometer recorded at Lerwick, during practically the entire month.

The number of days with fog was somewhat below normal over the Grand Banks and middle section of the steamer lanes, and above off the coast of Europe and that part of the American coast between the thirty-fifth and fortieth parallels, as well as in the Gulf of Mexico.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, 8 a. m. (seventy-fifth meridian). North Atlantic Ocean, February, 1929*

Stations	Average pressure	Departure [1]	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland	29.45	([2])	29.92	18th	28.62	21st.
Belle Isle, Newfoundland	29.88	+0.13	30.46	7th	29.40	23d.[3]
Halifax, Nova Scotia	30.08	+0.10	30.54	6th	29.56	20th.
Nantucket	30.07	+0.01	30.44	13th	29.76	1st.[3]
Hatteras	30.10	−0.03	30.42	24th	29.68	28th.
Key West	30.04	−0.04	30.16	2d [3]	29.84	6th.
New Orleans	30.07	−0.03	30.46	23d	29.78	26th.[3]
Cape Gracias, Nicaragua	29.92	−0.05	29.98	3d [3]	29.84	6th.
Turks Island	30.11	+0.03	30.18	21st [3]	29.98	5th.
Bermuda	[4] 30.18	+0.04	30.42	26th	29.82	17th.
Horta, Azores	30.05	−0.08	30.60	10th	29.26	18th.
Lerwick, Shetland Islands	30.07	+0.35	30.61	28th	29.73	23d.
Valencia, Ireland	29.87	−0.03	30.57	28th	29.52	15th.
London	30.09	+0.09	30.74	28th	29.65	24th.

[1] From normals shown on Hydrographic Office Pilot Chart, based on observations at Greenwich mean noon, or 7 a. m., seventy-fifth meridian time.
[2] No normal available.
[3] And on other date or dates.
[4] Average of 24 observations.

On the 1st there were two depressions over the ocean; the first central about 200 miles east of Nantucket and the second near 57° N., 35° W. By the 2d both of these LOWS had moved eastward and moderate to strong gales prevailed between the Bermudas and Newfoundland and westerly winds of force 7 to 8 over the eastern section of the steamer lanes. On the 3d strong gales occurred between the forty-fifth and fiftieth parallels and thirtieth and forty-fifth meridians, as well as off the coast of Spain.

From the 4th to 10th moderate weather was the rule, with the exception of a disturbance from the 8th to 10th, north of the fifty-fifth parallel and east of the thirtieth meridian. On the 11th St. Johns, Newfoundland, was near the center of a LOW, with moderate to strong westerly gales in the southerly quadrants. From the 11th to 14th land stations on the coast of Great Britain, as well as vessels in the vicinity, reported easterly to southerly winds of force 7 to 9.

On the 12th northwesterly winds of hurricane force were encountered near mid-ocean, as shown by report from the American S. S. *Sagaporack* in table.

On the 14th an area of high pressure was over eastern Canada, with a barometric reading of 30.50 inches at Sydney, while a vessel near Bermuda reported a reading of 29.57 inches. The steep gradient was responsible for easterly winds of gale force over the area between these two localities, accompanied by comparatively high barometric readings.

Charts VIII to XI show the conditions from the 15th to 18th, inclusive, when the most extensive and severe disturbance of the month covered a large portion of the ocean, the storm area extending as far south as the thirtieth parallel. On the 19th the center of this LOW was near 48° N., 30° W., and strong northerly gales still prevailed in the westerly quadrants, while southerly winds of force 7 to 9 also occurred between the forty-fifth and fiftieth parallels, east of the twentieth meridian. By the 20th the conditions had moderated somewhat, but on the 21st the middle section of the steamer lanes was covered by a well developed disturbance, while southerly gales were also reported along the American coast, between Hatteras and New York.

On the 22d the western disturbance was central off the west coast of Newfoundland, the storm area extending to the thirtieth parallel, while northerly gales also occurred between the Azores and the fifty-fifth parallel and the twenty-fifth and thirtieth meridians. On this date the trade wind in the Caribbean Sea was unusually strong, as shown by report in table from Danish M. S. *Asia*.

A disturbance that on the 24th was central near 42° N., 40° W., moved rapidly eastward, and from this date until the 27th westerly gales swept the middle and eastern sections of the steamer lanes, between the fortieth and fiftieth parallels.

WATERSPOUT

Capt. B. W. Lyons, master of the S. S. *Canadian Britisher*, has furnished the Weather Bureau with the following description of a waterspout observed by him on February 18, 1929, in the Florida Straits:

> Position, latitude 25° 50′ N., longitude 79° 45′ W.; wind NE., 2, temperature of air, 76°, sea, 77°. Witnessed when first forming, at 9 a. m., at which time the waterspout appeared as a cone-shaped mass let down from nimbus cloud, altitude about 1,500 feet. At 9:05 a. m. the spout had reached the sea beyond the horizon.
>
> The waterspout was a perfectly vertical, slender column, retaining its uprightness throughout, but gradually becoming very large in diameter—about 100 feet. It traveled in a southeasterly direction with a clockwise movement until within about 4 miles of the ship, when, beginning at the surface of the sea, it gradually broke away and drew up to the clouds. By 9:20 a. m. it had dispersed.
>
> During the progression of the waterspout the sea was heavily agitated at its base, and it appeared that a heavy mist, similar to that accompanying a waterfall, was raised all around it from the sea to a height of about 100 feet. In the immediate rear was a "wake" of agitated water and, trailing, lower lying mist by which the direction traveled could be easily determined.

A photograph of the waterspout as it appeared at 9.15 a. m. is reproduced herewith.

OTHER WATERSPOUTS

Vega, U. S. S.; Capt. F. M. Robinson, commander, U. S. N.; observer, O. B. Earle, lieutenant, U. S. N.; Corinto to Boston; 1 p. m., February 3 in 34° 20′ N., 74° 52′ 30″ W.

> Upon entering Gulf Stream the temperature of the water was 68°, while that of the air was 42°. This resulted in rapid evaporation of sea water, and numerous steam jets could be seen rising from surface of sea. In many cases the steam formed vapor spouts with the appearance of waterspouts at a distance. These

FIGURE 1.—Waterspout observed by Capt. B. W. Lyons, master S. S. *Canadian Britisher*, February 18, 1929, in latitude 25° 50′ N. and longitude 79° 45′ W.

vapor spouts rose until they reached the clouds, twisting and turning as a true waterspout. When the edge of the Gulf Stream was reached there was a well-defined line between the current and ocean, and the temperature of water dropped suddenly some 20 degrees upon crossing the line in 35° 45′ N., 75° 09′ W. at 5:40 p. m.

Steel Ranger, American S. S.; Capt. R. C. Forbes; observers, ship's officers; Port Said to Newport News.

From 10 to 10:20 a. m. on the 28th a large waterspout was observed about 6 miles north of ship in 32° 03′ N., 31° 58′ W., moving east slowly, temperature of air 65°. This appeared the usual funnel shape protruding from a dark nimbus cloud. On the sea level considerable disturbance was noticed.

Coahoma County, American S. S.; Capt. Robert J. K. Doring; observer, R. Jensen; February 9, in 38° 47′ N., 53° 50′ W., at 10:15 a. m., local mean time.

Observed a large waterspout apparently traveling in a southeasterly direction. The funnel-shaped cloud overhead, which was very conspicuous and extended to a considerable height, curved at quite an angle to its path of progression. Altogether, about five minutes elapsed before it passed out of sight. It formed very rapidly and was at first mistaken for a ship on fire at a distance. The clouds overhead were strato-cumulus and to our northwest was a small rain squall. The wind was SSW., force 5, aboard ship.

OCEAN GALES AND STORMS FEBRUARY, 1929

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				Inches					
Mercier, Belg. S. S.	Antwerp	New York	49 47 N.	30 00 W.	Feb. 1	8 a., 1	Feb. 2	29.13	S	S., 9	W	SW., 11	S.-WSW.
Samland, Belg. S. S.	do	do	42 10 N.	56 46 W.	1	10 a., 2	3	29.08	WNW	N., 6	N	NW., 10	SW.-W.-NW.
President Monroe, Am. S. S.	Marseille	do	37 36 N.	50 23 W.	2	2 p., 2	3	29.57	S	SW., 10	WNW	SW., 10	Steady.
Mercier, Belg. S. S.	Antwerp	do	48 08 N.	39 50 W.	3	11 a., 3	4	29.26	S	SW., 11	WSW	SW., 11	S.-W.-WSW.
Arminco, Belg. S. S.	Port Arthur	Liverpool	42 35 N.	53 10 W.	10	8 a., 11	11	29.73	SW	NW., 8	N	NW., 9	SW.-NW.
Sagaporack, Am. S. S.	Bergen	Portland, Me.	54 40 N.	32 30 W.	8	2 a., 12	13	29.29	WSW	SW., 10	NW	W., 12	
West Hika, Am. S. S.	Mobile	Rotterdam	49 42 N.	6 28 W.	11	1 a., 12	13	29.47	E	E., 8	E	E., 11	Steady.
Cold Harbor, Am. S. S.	Boston	Manchester	52 08 N.	6 09 W.	12	7 a., 13	13	29.54	SE	SE., 9	SE	SE., 9	Steady.
Leopold L. D., Fr. S. S.	Gibraltar	Philadelphia	37 49 N.	71 04 W.	13	6 a., 14		29.83	E	NNE., 11		NNE., 11	
West Celina, Am. S. S.	Houston	Liverpool	39 06 N.	54 06 W.	14	8 a., 14	16	29.27	W	SW., 8	NW	W., 12	SW.—NW.
Mississippi, Br. M. S.	Halifax	London	45 15 N.	50 30 W.	15	2 a., 15	20	28.52	E	NE., 11	NW	NE., 11	E.-NNE.
George Peirce, Am. S. S.	Galveston	Bremen	43 46 N.	38 55 W.	14	9 p., 16	16	28.39	WSW	N., 4	N	SE., 12	
Sitoebondo, Du. S. S.	Dutch East Indies.	New York	37 10 N.	62 35 W.	14	5 p., 16	17	29.46	SE	SW., 9	NW	SSW., 10	SW.-W.
Gonzenheim, Ger. S. S.	Norfolk	Bremen	41 31 N.	46 51 W.	15	4 a., 16	17	28.85	SW	WNW., 12	NNW	—, 12	WSW.-WNW.
Vulcania, Ital. M. S.	Gibraltar	New York	41 30 N.	46 02 W.	15	4 a., 16	16	28.88	E	WSW., 11	WNW	WNW., 12	WSW.-WNW.
West Arrow, Am. S. S.	Antwerp	do	38 15 N.	39 06 W.	15	—, 16	17	29.46	SSW	W., 11	NW	W., 11	WSW.-W.
München, Ger. S. S.	New York	Cobh	40 44 N.	55 30 W.	16	3 a., 17	19	28.89	S	WSW., 4	NW	NW., 11	S.-WSW.
West Celina, Am. S. S.	Houston	Liverpool	42 00 N.	39 35 W.	18	9 a., 18	20	29.47	NW	NW., 10	NW	NW., 10	WNW.-NW.
Samland, Belg. S. S.	New York	Antwerp	49 15 N.	12 40 W.	19	8 a., 19	20	29.68	SSE	—, 10	SSE	S., 10	
Asia, Fr. S. S.	Providence	Lisbon	40 00 N.	51 52 W.	20	5 p., 20	20	29.74	SSW	SSW., 12	SSW	SSW., 12	SSW.-W.
Berlin, Ger. S. S.	New York	Bremerhaven	40 19 N.	70 29 W.	21	4 p., 21	22	29.35	E	SSW., 5	W	ESE., 10	ESE.-S.-SW.
Albert Ballin, Ger. S. S.	Hamburg	New York	43 00 N.	41 00 W.	21	4 a., 21	21	29.75	SW	W., 8	NNW	NW., 10	
Asia, Dan. M. S.	St. Thomas	Canal Zone	11 25 N.	77 05 W.	21	4 p., 22	22	29.88	ENE	ENE., 8	NNE	NE., 9	ENE.-NE.
Egremont, Am. S. S.	Port Said	Boston	36 30 N.	54 30 W.	23	6 a., 23	24	29.83	WSW	WSW., 8	WNW	WNW., 10	WSW.-NNW.
City of Alton, Am. S. S.	Rotterdam	do	39 22 N.	46 38 W.	23	2 a., 24	26	29.08	W	WSW., 10	NW	NW., 12	WSW.-NW.
Yeifuku Maru, Jap. S. S.	New York	Hamburg	45 38 N.	34 05 W.	24	4 p., 24	26	28.05	SSE	W., 12	WNW	W., 12	W.-NW.
Shenandoah, Am. S. S.	Port Arthur	Dublin	44 50 N.	34 37 W.	24	6 p., 24	26	28.42	SSE	WSW., 12	WSW	—, 12	W.-WSW.
Saco, Am. S. S.	Antwerp	Boston	48 22 N.	35 29 W.	24	Noon, 24	27	29.37	E	E., 6	WNW	WSW., 12	W.-WSW.
Patagonier, Belg. S. S.	do	New York	48 29 N.	29 53 W.	24	2 a., 25	26	28.01	SE	SE., —	W	SE., 12	SSE.-W.
Anacortes, Am. S. S.	New York	Glasgow	49 29 N.	37 27 W.	24	8 a., 25	25	28.83	NW	NW., —	W	NW., 11	NW.-N.-NW.
Grete, Ger. S. S.	Charleston	Bremen	42 30 N.	41 30 W.	28	8 p., 28	Mar. 1	29.23	SSW	W., 6	WSW	—, 9	SSE.-W.-WSW.
NORTH PACIFIC OCEAN													
China Arrow, Am. S. S.	Hong Kong	San Pedro	40 19 N.	169 07 W.	Feb. 2	10 a., 3	3	29.51	SSE	SSW., 7	SSW	SSE., 9	SSE.-SSW.
Milluna, Br. S. S.	Sydney	Yokohama	27 55 N.	142 35 E.	2	2 p., 2	3	29.28	NW	NW., —	NW	NW., 10	Steady.
President Madison, Am. S. S.	Honolulu	do	34 35 N.	155 10 E.	2	p., 2	3	28.80		WSW., 8	NW	WNW., 10	WSW.-WNW.
Taibu Maru, Jap. S. S.	Miike	William Head	47 52 N.	177 10 W.	3	4 p., 3	3	28.19	SSE	SSE., 7	S	SE., 9	SE.-S.
Tahchee, Br. S. S.	San Pedro	Yokohama	31 07 N.	171 28 E.	3	Noon, 3	3	29.51	S	S., 9	WSW	WSW., 10	S.-WSW.
Pennsylvania, Am. S. S.	Yokohama	San Francisco	47 15 N.	176 50 E.	3	2 a., 4	4	28.03	SE	S., 8	SW	SSW., 9	SE.-S.-SW.
Emp. of Asia, Br. S. S.	do	Vancouver	46 58 N.	170 12 E.	3	8 a., 4	4	27.84	NNW	W., 11	S	W., 11	NNW.-W.-S.
California, Am. S. S.	Otaru	San Francisco	47 00 N.	159 00 W.	5	3 a., 5	5	28.77	S	S., 10	SW	S., 10	S.-SW.
Golden Peak, Am. S. S.	San Francisco	Yokohama	31 43 N.	175 50 W.	8	4 p., 8	8	29.48	S	SSW., 8	WSW	SSW., 8	S.-WSW.
Hayo Maru, Jap. S. S.	Muroran	Vancouver	49 21 N.	162 05 W.	8	Noon, 9	9	28.98	SSE	SE., 8	S	SE., 10	SE.-S.
Dalblair, Br. S. S.	Moji	Portland	49 35 N.	166 10 W.	8	3 a., 9	9	28.49	SE	SE., 11	SW	SE., 11	
Hawaii Maru, Jap. S. S.	Los Angeles	Yokohama	32 18 N.	160 45 E.	8	9 p., 10	10	29.44	SSW	NW., 5	NW	SW., 9	WSW.-NW.
Reiyo Maru, Jap. S. S.	Vancouver	Osaka	54 35 N.	172 05 W.	9	2 p., 9	11	27.95	E	SE., 11	SSW	SE., 11	SE.-S.
Steel Voyager, Am. S. S.	Honolulu	Yokohama	34 45 N.	140 00 E.	9	8 p., 12	13	29.44	SW	W., 7	SW	WNW., 11	W.-WSW.
Chief Capilano, Br. S. S.	Shanghai	Muroran	39 11 N.	136 57 E.	10	4 p., 10	10	29.54	NNW	WNW., 7	NW	NW., 9	WNW.-NW.
Wisconsin, Am. S. S.	Hong Kong	San Francisco	34 10 N.	148 00 E.	10	2 a., 11	11	29.42	WNW	NW., 11	NW	NW., 11	WNW.-NW.
Ryufuku Maru, Jap. S. S.	Canal Zone	Yokohama	28 53 N.	159 10 E.	10	5 a., 11	12	29.50	SW	WSW., 4	WNW	W., 9	
Koyo Maru, Jap. S. S.	Miike	Portland	46 55 N.	172 15 W.	10	Mdt., 10	12	29.23	SSW	SE., 7	S	SSE., 9	SSW.-SE.-S.
Mojave, Am. S. S.	San Pedro	Balboa	15 07 N.	96 03 W.	11	3 a., 11	11	29.95	ENE	ENE., 6	NNE	NNE., 10	
Golden Peak, Am. S. S.	San Francisco	Yokohama	32 00 N.	178 00 E.	11	2 a., 12	13	29.48	S	SW., 8	WNW	W., 10	S.-SW.-W.
Montana, Am. S. S.	China	Seattle	49 40 N.	173 10 W.	12	6 a., 12	12	28.46	SE	SE., 7	SW	SW., 10	S.-SW.
Hawaii Maru, Jap. S. S.	Los Angeles	Yokohama	33 42 N.	152 14 E.	11	2 a., 13	14	29.12	SW	SSW., 11	WNW	SSW., 11	S.-SW.-W.
Dryden, Am. S. S.	Honolulu	do	30 35 N.	146 15 E.	12	10 p., 12	14	29.55	SW	SW., 7	NW	W., 9	SW.-W.
Wisconsin, Am. S. S.	Hong Kong	San Francisco	36 50 N.	155 00 E.	13	8 a., 13	13	28.83	SW	SW., 10	NW	NW., 12	SW.-NW.
Pres. Jackson, Am. S. S.	Honolulu	Yokohama	33 10 N.	162 18 E.	13	7 a., 14	14	29.46	SSW	WSW., 8	W	S., 9	SW.-W.
Tatsuno Maru, Jap. S. S.	Yokohama	San Francisco	40 50 N.	158 00 E.	13	2 p., 13	15	28.84	NE	N., 7	W	NW., 9	5 pts.
Shabonee, Br. S. S.	Nagasaki	San Pedro	41 52 N.	176 00 E.	18	6 a., 18	19	29.00	NW	NW., 7	NW	WNW., 9	NW.-WNW.
Tahchee, Br. S. S.	Yokohama	do	39 38 N.	150 43 E.	18	9 a., 18	20	28.66	SE	S., 7	NNW	E., 11	S.-E.
Golden Sun, Am. S. S.	San Francisco	Kobe	38 04 N.	148 45 E.	19	2 p., 19	20	29.08	SSE	NNW., 9	NW	NNW., 10	SSE.-NNW.
Hakubasan Maru, Jap. S. S.	Yokohama	Seattle	44 21 N.	156 00 E.	19	Noon, 21	22	28.74	ENE	W., 6	W	NE., 9	
Hamburg Maru, Jap. S. S.	do	San Francisco	37 40 N.	167 02 E.	19	4 p., 20	25	29.42	SSE	SW., 8	NNW	SW., 9	
Chief Capilano, Br. S. S.	Muroran	Vancouver	50 00 N.	178 45 E.	20	Mdt. 21	24	28.85	ESE	ESE., 5	SW	ESE., 10	ESE.-S.
Manukai, Am. S. S.	Hawaii	San Francisco	23 05 N.	154 48 W.	21	3 p., 21	21	29.83	NNE	NE., 8	NE	NE., 8	NE.-N.
Alabama Maru, Jap. S. S.	Yokohama	Victoria	50 15 N.	156 15 W.	22	2 a., 23	25	28.77	SSE	S., 9	W	S., 9	
Olympia, Am. S. S.	Wei Hai Wei	San Francisco	47 08 N.	163 36 E.	25	Noon, 25	Mar. 3	29.34		E., 8	W	E., 9	Steady.

NORTH PACIFIC OCEAN

By WILLIS E. HURD

During February the average position of the Aleutian cyclone lay between the northwestern portion of the Gulf of Alaska and the waters to the south of Kamchatka, with the central area west of the Alaskan Pensinsula, lowest monthly pressure given, 29.42 inches, at Dutch Harbor. On the 17th the great region of low pressure expanded eastward until it covered the whole upper part of the Gulf of Alaska, where it affected the weather until the close of the month. On two occasions early in February, during the 3d and 4th and on the 9th and 10th, the cyclone became unusually expanded southward and centrally intensified, covering an enormous area in upper and middle latitudes, and with local pressures below 28 inches. The lowest recorded barometer, 27.84 inches, occurred on the 4th and was read on board the steamship *Empress of Asia* in 46° 58′ N., 170° 12′ E. An almost equally low reading, 2.795 inches, was recorded by the steamship *Reiyo Maru* in 54° 35′ N., 172° 05′ W., on the 9th.

The Pacific-California anticyclone was generally well developed and covered its usual area, except for a few days, principally early in the month, when intruding low pressures, north and east, restricted its region of activity.

Anticyclones prevailed the greater part of the month off the China coast, causing strong monsoon winds on several days. Frequent cyclones, mostly small and of a moderate nature, occurred in the neighborhood of Japan.

Pressure data for several island and mainland coast stations in west longitudes are given in the following table:

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level at indicated hours, North Pacific Ocean and adjacent waters, February, 1929*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Point Barrow [1]	30.22		30.68	20th [5]	29.80	10th.
Dutch Harbor [1] [2]	29.42	−0.20	30.06	18th	28.54	5th.
St. Paul [1] [2]	29.54	−0.12	30.24	19th	28.58	6th.
Kodiak [1]	29.74	+0.04	30.26	13th	28.66	23d.
Midway Island [1] [2]	29.96	−0.07	30.18	18th	29.68	8th.
Honolulu [3]	30.01	−0.04	30.13	1st	29.83	11th.
Juneau [3]	30.10	+0.18	30.59	10th	29.30	19th.
Tatoosh Island [3] [4]	30.20	+0.22	30.46	10th	29.67	1st.
San Francisco [3] [4]	30.11	+0.04	30.35	10th	29.75	6th.
San Diego [3] [4]	30.07	+0.03	30.26	10th	29.76	6th.

[1] P. m. observations only.
[2] 1 day missing.
[3] A. m. and p. m. observations
[4] Corrected to 24-hour mean.
[5] And on 21st.

Gales occurred somewhere over upper and middle sections of the ocean on almost every day of February, except in the region dominated by the Pacific-California anticyclone, where they were largely confined to a restricted region west of the middle California coast on the 2d and 3d. In addition, a moderate gale was encountered northeast of Hawaii on the 21st. The northern and middle latitude western areas were somewhat stormier than in January, and whole gales to full storm winds were rather frequent. Forces of 11 occurred on the 4th near 47° N., 170° E.; on the 9th, 10th, 11th, and 14th both north and south of the central and eastern Aleutian Islands; and on the 10th, 11th, 13th, and 19th between Japan and 160° E., 30° and 40° N. On the 13th a full hurricane velocity, the only one yet reported for February, was experienced in 37° N., 155° E. Gales in east longitudes occurred on several days in as low a latitude as the 25th parallel. High winds were reported in the Japan Sea on the 2d and 10th, although conditions show they occurred there also on other dates, and in or near Yokohama Harbor on the 12th and 13th. For the Japanese coast as a whole the stormiest days seem to have been the 2d, 3d, 13th, 19th, 24th, and 25th, the gales being due in part to the passage of active cyclones, but largely to the steep pressure gradients at times existing between the upper Asiatic coast and the western extension of the Aleutian cyclone. Snow was frequent over the waters of the archipelago, and heavy snow, hail, and sleet squalls were often encountered between northern Japan and the Aleutian Islands.

The prevailing wind at Honolulu was from the east; the highest wind velocity was at the rate of 25 miles an hour from the east on the 17th.

A violent norther was experienced in the Gulf of Tehuantepec on the 11th. The gale reported was from NNE., force 10, and resulted from a strong flow of air over the isthmus from an anticyclone of some magnitude central that day over Texas.

Winter fog conditions prevailed, with little change in locality and general percentage of occurrence from those of the previous December and January. Fog formed in the North China Sea and the Gulf of Tonkin on the 22d; otherwise, in east longitudes no fog was reported except along the upper route near mid-ocean, where it was observed on the last few days of the month. Most frequent fog was found along the upper and middle steamer routes between longitudes 140° and 170° W., with the region of maximum formation, 30 to 40 per cent of the days, near 50° N., 145° to 160° W. It was reported on a few days off the Washington coast and near Cape San Lucas, but for the most part the American coast seems to have been unusually free from fog this month.

CLIMATOLOGICAL TABLES[1]

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, February, 1929

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	46.0	−2.3	5 stations	78	[2] 8	St. Bernard	12	1	9.13	+3.83	River Falls	16.75	Florence	4.44
Arizona	44.0	−4.2	Yuma Citrus Station.	87	23	Flagstaff	−21	9	0.80	−0.38	Waters Ranger Station.	2.95	5 stations	0.00
Arkansas	35.4	−7.4	Portland	76	25	Lead Hill	−20	10	4.01	+0.66	Waldron	6.29	Amity	1.97
California	44.0	−3.2	Imperial	88	23	South Lake	−18	8	2.24	−2.20	Squirrel Inn	10.16	4 stations	0.00
Colorado	19.6	−8.4	Canon City	74	22	3 stations	−40	[2] 9	0.96	−0.02	Cumbres	4.35	Blanca	T.
Florida	63.7	+3.5	2 stations	92	[2] 26	3 stations	26	12	2.14	−1.00	Cottage Hill	10.43	Fort Myers	0.08
Georgia	48.9	+0.9	Waycross	86	27	Blue Ridge	12	1	8.63	+3.63	Butler	14.80	Bainbridge	2.07
Idaho	19.7	−9.6	2 stations	57	[2] 16	Felt	−44	7	0.90	−0.83	Musselshell	3.47	Twin Falls Factory	T.
Illinois	23.4	−5.1	Anna	61	26	Mount Carroll	−30	20	1.27	−0.68	Grand Chain	4.61	Waukegan	0.27
Indiana	25.1	−4.5	Mount Vernon	64	26	3 stations	−18	20	1.88	−0.66	Bedford	2.86	Fowler	0.33
Iowa	14.0	−8.6	Keokuk	52	23	Decorah	−35	20	1.31	+0.10	Iowa Falls	3.03	Chariton	0.34
Kansas	25.0	−7.5	Elkhart	69	23	Oberlin	−20	[2] 8	0.83	−0.33	Salina	2.31	Richfield	0.04
Kentucky	31.2	−5.4	2 stations	68	26	Farmers	−14	23	3.58	+0.13	Marion	6.30	Scott	1.55
Louisiana	49.7	−3.5	Angola	87	25	Tallulah	17	12	6.46	+1.97	Franklinton	10.58	Shreveport	2.54
Maryland-Delaware	33.0	0.0	Salisbury, Md	72	26	Oakland, Md	1	[2] 20	3.69	+0.65	Public Landing, Md.	6.81	Friendsville, Md	1.99
Michigan	16.1	−3.2	Monroe	54	26	Atlanta	−44	20	0.94	−0.75	Sack Bay	2.20	Edmore	0.18
Minnesota	5.6	−6.3	Leech Lake Dam	44	26	Taylors Falls	−43	19	0.52	−0.18	New Ulm	1.45	Redby	T.
Mississippi	45.1	−4.0	Monticello	82	25	Pontotoc	14	11	6.16	+1.41	Merrill	14.75	Austin	2.17
Missouri	25.0	−7.4	Caruthersville	64	26	3 stations	−23	10	1.92	−0.19	Campbell	5.90	Valley Park	0.32
Montana	12.6	−8.3	Livingston	53	2	Conways Ranch	−46	7	0.64	−0.12	Hebgen Dam	3.19	Conrad	0.00
Nebraska	17.7	−7.4	Franklin	59	23	Gordon	−31	19	1.01	+0.29	Falls City	2.34	Mitchell (near)	0.19
Nevada	30.0	−4.9	2 stations	72	[2] 22	Owyhee	−23	8	0.57	−0.35	Tuscarora	1.53	2 stations	T.
New England	23.3	+0.8	Plymouth, Mass	60	7	Van Buren, Me	−34	14	3.29	+0.05	Nantucket, Mass	5.76	Ripogenus Dam, Me.	0.93
New Jersey	31.6	+2.2	Indian Mills	63	19	Layton	−9	24	4.06	+0.42	Chatham	5.92	Newton	2.76
New Mexico	31.4	−6.4	Carlsbad	75	18	Dulce	−33	9	0.74	+0.03	Winsors Ranch	2.74	Pearl	T.
New York	23.0	+1.1	3 stations	59	[2] 9	Stillwater	−28	20	2.48	−0.30	Roslyn	5.19	Lauterbrunnen	0.65
North Carolina	41.1	−1.0	3 stations	76	[2] 27	Mount Mitchell	4	12	6.38	+2.22	Tryon	9.78	Hot Springs	2.84
North Dakota	2.9	−5.0	Carson	44	25	3 stations	−44	19	0.29	−0.20	3 stations	0.80	4 stations	T.
Ohio	25.1	−4.3	4 stations	61	26	Norwalk	−25	20	2.37	−0.02	Wilmington	4.64	2 stations	0.76
Oklahoma	31.4	−9.7	Hollis	73	24	Kingfisher	−20	10	1.49	+0.08	Smithville	5.36	Supply	0.19
Oregon	30.0	−7.0	Grants Pass	68	28	Meacham	−39	7	1.02	−2.70	Government Camp	4.85	Milton	0.00
Pennsylvania	28.0	+0.3	Claysville	69	27	Brookville	−20	20	2.87	+0.21	Mount Pocono	5.17	Erie	1.36
South Carolina	45.2	−2.1	2 stations	82	26	Hogback Mountain	12	1	7.85	+3.44	Calhoun Falls	11.42	Conway	4.07
South Dakota	10.2	−7.8	Hot Springs	52	25	Pollock	−50	19	0.66	+0.05	Harveys Ranch	2.20	Cottonwood	0.04
Tennessee	36.6	−4.2	2 stations	72	[2] 25	Lebanon	0	23	4.99	+0.64	Copperhill	8.00	Bristol	2.92
Texas	44.0	−6.5	Riogrande	93	24	Romero	−16	9	1.30	−0.56	Wiergate	6.07	10 stations	0.00
Utah	23.4	−7.6	St. George	70	6	Loa	−37	8	1.36	+0.25	Silver Lake	5.06	Wendover	0.01
Virginia	35.5	−1.7	2 stations	73	26	Hot Springs	0	3	4.05	+0.97	Clarksville	7.41	Deerfield	1.27
Washington	25.1	−9.4	Centralia	60	24	2 stations	−27	[2] 7	1.40	−2.63	Cedar Lake	6.96	9 stations	0.00
West Virginia	30.0	−2.3	Wardensville	70	27	Ryan	−15	23	2.98	−0.03	Bayard	5.24	Wellsburg	1.47
Wisconsin	10.1	−5.6	High Falls	53	27	2 stations	−48	[2] 19	1.18	+0.05	Shawano	2.24	Prairie du Sac	0.20
Wyoming	12.7	−9.1	Chugwater	52	2	Border	−60	8	0.83	+0.04	Snake River	3.24	Dubois	T.
Alaska (January)	14.6	+9.8	2 stations	52	[2] 9	Eagle	−54	26	3.49	+0.66	Chignik	15.45	Fort Yukon	0.44
Hawaii	68.5	+0.2	Kaanapali	92	3	Volcano Observatory	45	5	11.18	+4.75	Puohakamoa	57.36	Waiawa	0.41
Porto Rico	73.5	+0.1	San German	93	28	Guineo	47	17	2.43	−0.45	Totro Negro	5.70	Coamo	0.56

[1] For description of tables and charts, see REVIEW, January 1929, p. 36.

[2] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, February, 1929*

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England							27.1	+1.7										77	3.60	+0.3										5.5		
Eastport	76	67	85	29.97	30.06	+0.08	23.7	+2.2	43	7	30	2	13	17	23	22	17	76	2.15	−1.2	11	6,278	nw.	36	ne.	21	8	4	16	6.6	14.2	1.0
Greenville, Me.	1,070	6	......	28.85	30.08	......	15.8	......	43	18	26	−12	13	6	45	......	......	......	2.20	......	13	......	n.	......	......	......	8	13	6	9	......	21.8	......
Portland, Me.	103	82	117	29.98	30.10	+.08	26.2	+2.4	45	18	33	4	24	19	25	23	18	73	4.33	+0.3	13	4,667	n.	28	sw.	18	15	3	10	4.7	26.9	7.3
Concord	289	70	79	29.77	30.10	+.06	23.2	+0.4	53	18	34	−13	24	13	43	......	......	......	3.70	+0.8	10	2,944	nw.	23	sw.	18	9	9	10	5.1	32.0	13.1
Burlington	403	11	48	29.64	30.12	+.09	19.0	−0.4	44	18	27	−6	24	11	33	......	......	......	1.38	−0.2	11	4,686	s.	36	s.	26	3	7	18	7.4	13.8	5.6
Northfield	876	12	60	29.12	30.11	+.07	16.5	+0.1	47	18	28	−17	24	5	44	14	12	87	3.00	+0.8	11	3,746	n.	31	s.	26	4	11	13	6.8	32.3	18.5
Boston	125	115	188	29.94	30.08	+.04	31.7	+2.9	56	18	38	14	24	25	21	28	23	74	3.78	+0.4	12	5,584	nw.	27	se.	26	11	7	10	5.3	21.4	3.7
Nantucket	12	14	90	30.04	30.04	.00	33.2	+2.5	53	27	39	19	24	27	22	30	28	84	5.76	+2.4	12	8,352	nw.	42	e.	7	8	9	11	6.3	12.0	0.0
Block Island	26	11	46	30.02	30.06	.00	32.4	+2.0	48	18	37	18	13	28	21	30	26	78	3.28	−0.4	10	10,747	nw.	48	e.	21	12	8	8	4.8	4.2	0.3
Providence	160	215	251	29.90	30.08	+.03	31.3	+2.3	52	18	38	13	24	24	22	27	21	68	3.04	−0.6	13	6,874	n.	42	se.	7	13	6	9	4.9	12.2	1.6
Hartford	159	122	......	29.91	30.10	+.04	29.8	+2.6	53	18	37	8	5	22	26	......	......	......	4.73	+0.9	11	......	nw.	......	......	......	14	6	8	4.1	9.9	0.3
New Haven	106	74	153	29.98	30.10	+.03	30.8	+1.8	54	27	38	14	5	24	20	27	22	74	4.42	+0.4	11	5,642	n.	29	e.	7	11	9	8	4.6	8.4	0.0
Middle Atlantic States							33.5	+0.1										74	3.76	+0.6										5.6		
Albany	97	107	115	30.01	30.12	+.05	24.9	+0.8	54	18	33	−3	24	17	36	22	18	78	3.68	+1.2	9	3,947	nw.	17	sw.	18	12	9	7	4.8	18.8	6.0
Binghamton	871	10	84	29.14	30.10	+.02	24.3	+0.3	49	18	32	−3	23	17	41	......	......	......	2.31	0.0	9	3,259	nw.	15	w.	27	3	6	19	7.7	11.8	1.0
New York	314	414	454	29.75	30.10	+.02	33.4	+2.1	55	18	41	14	20	26	26	28	21	64	4.30	+0.5	7	9,516	nw.	40	nw.	1	8	10	10	5.6	9.0	0.0
Bellefonte, Pa.	1,050	5	36	28.96	30.11	......	24.0	......	53	25	34	−3	5	14	44	21	17	78	2.28	......	8	......	w.	......	......	......	5	10	13	7.0	8.9	1.9
Harrisburg	374	94	104	29.71	30.13	+.04	30.9	+0.7	55	18	38	13	20	24	26	26	20	65	3.21	+0.2	9	4,101	nw.	26	nw.	1	6	15	7	5.6	11.6	0.0
Philadelphia	114	123	367	29.99	30.12	+.02	35.2	+1.3	58	18	42	17	20	28	29	31	25	70	4.24	+0.9	8	8,251	nw.	34	nw.	1	11	8	9	5.1	8.2	0.0
Reading	325	81	98	29.75	30.12	......	32.6	......	57	18	40	13	24	25	30	28	24	76	3.76	+0.3	7	4,114	nw.	23	se.	26	12	9	7	4.8	11.3	0.0
Scranton	805	111	119	29.22	30.11	+.03	28.3	+1.0	52	27	35	7	5	22	32	25	21	76	1.85	−1.2	8	4,055	n.	31	sw.	18	2	8	18	7.9	7.5	0.4
Atlantic City	52	37	172	30.04	30.10	−.01	35.6	+1.4	53	26	42	18	4	28	20	32	28	78	4.33	+1.0	12	9,880	nw.	45	e.	21	13	6	9	4.4	7.5	0.0
Cape May	17	13	49	......	......	......	35.3	+1.2	56	25	42	17	4	28	25	31	28	80	4.76	+1.5	13	......	nw.	......	......	......	9	8	11	......	~~9.3~~	~~0.0~~
Sandy Hook	22	10	55	30.07	30.10	......	32.4	......	52	18	38	17	23	27	18	29	25	78	3.72	0.0	7	9,264	nw.	38	ne.	21	9	10	9	4.9	6.6	0.0
Trenton	190	159	183	29.88	30.10	......	33.0	......	58	18	41	14	20	25	29	28	23	72	3.51	+0.2	7	6,245	nw.	26	ne.	7	10	9	9	5.2	7.9	0.0
Baltimore	123	100	215	29.98	30.11	.00	35.6	+0.2	63	18	43	19	2	28	27	30	24	65	3.45	+0.1	8	5,900	nw.	33	se.	26	13	6	9	4.7	11.2	0.0
Washington	112	62	85	30.00	30.12	+.01	35.0	−0.3	64	19	44	17	2	26	32	30	23	67	3.19	−0.1	9	3,897	nw.	27	nw.	1	13	6	9	5.1	7.0	0.0
Cape Henry	18	8	54	30.07	30.09	......	40.1	......	73	26	47	23	2	33	32	36	33	81	5.25	+2.0	11	8,083	n.	38	n.	20	8	7	13	6.1	3.9	0.0
Lynchburg	681	153	188	29.34	30.11	.00	38.2	−2.1	70	19	48	14	4	28	37	32	27	68	2.75	−0.4	10	3,873	w.	23	n.	20	13	5	10	5.1	7.6	0.0
Norfolk	91	170	205	30.02	30.12	+.01	41.3	−1.4	71	26	49	19	2	34	30	36	32	78	4.24	+1.0	12	7,377	n.	33	s.	26	10	4	14	5.9	2.9	0.0
Richmond	144	11	52	29.97	30.13	+.02	38.2	−1.4	67	26	48	16	2	29	32	33	29	77	5.19	+2.0	14	4,274	ne.	23	ne.	20	13	3	12	5.1	2.3	0.0
Wytheville	2,304	49	55	27.64	30.11	−.01	32.8	−2.3	65	26	42	10	2	24	34	29	24	75	3.93	+0.9	14	3,319	w.	27	sw.	26	10	5	13	6.1	17.3	0.0
South Atlantic States							46.9	−1.0										79	6.18	+2.5										6.4		
Asheville	2,253	70	84	27.67	30.10	−.03	37.8	−0.7	64	26	46	17	1	30	30	33	29	77	4.56	+1.4	13	5,609	se.	25	nw.	23	8	9	11	5.8	6.2	0.0
Charlotte	779	55	62	29.24	30.10	−.02	42.5	−1.4	73	26	51	23	2	34	28	37	33	74	8.58	+4.4	11	3,041	ne.	17	nw.	26	8	7	13	6.4	3.5	0.0
Greensboro	886	5	56	29.14	30.12	......	37.3	......	71	26	48	15	2	27	34	32	29	81	7.04	......	12	4,253	ne.	31	nw.	26	11	4	13	5.9	3.0	0.0
Hatteras	11	11	50	30.07	30.08	−.03	45.2	−2.2	70	26	51	27	2	39	25	42	40	85	7.07	+3.0	14	8,785	n.	34	n.	20	9	9	10	5.5	0.0	0.0
Raleigh	376	103	110	29.70	30.12	+.01	42.0	−1.2	73	28	51	19	2	33	20	37	34	81	6.90	+3.1	12	4,177	ne.	25	nw.	26	7	8	13	6.1	1.8	0.0
Wilmington	78	81	91	30.03	30.12	.00	47.3	−0.6	72	26	56	26	2	39	28	44	41	83	5.21	+2.0	13	3,881	n.	20	sw.	28	6	7	15	6.7	0.0	0.0
Charleston	48	11	92	30.03	30.08	−.04	51.1	−1.3	72	26	58	31	2	44	19	47	43	80	4.86	+1.9	12	6,070	ne.	24	ne.	5	5	6	17	7.1	0.0	0.0
Columbia, S. C.	351	41	57	29.71	30.11	.00	46.3	−1.9	75	26	55	26	2	38	31	42	38	79	6.96	+3.2	10	3,734	ne.	23	sw.	28	7	6	15	6.5	T.	0.0
Due West	711	10	55	29.34	30.13	......	43.7	......	71	26	52	24	1	35	27	......	......	......	9.69	......	11	4,528	ne.	28	nw.	26	6	9	13	6.6	~~0.5~~	~~0.0~~
Greenville, S. C.	1,039	139	146	28.96	30.08	......	42.8	−0.5	66	28	51	23	1	34	28	38	34	77	9.16	+4.0	12	4,498	ne.	30	w.	26	9	7	12	6.2	5.5	0.0
Augusta	182	62	77	29.88	30.08	−.04	49.0	−0.9	74	26	58	30	2	40	32	43	38	74	8.91	+4.8	13	2,944	nw.	20	nw.	21	6	9	13	6.6	0.0	0.0
Savannah	65	150	194	30.02	30.09	−.03	53.0	−1.0	78	26	61	33	2	45	26	48	44	81	4.38	+1.2	12	6,558	ne.	30	nw.	20	5	7	16	7.0	0.0	0.0
Jacksonville	43	209	245	30.02	30.07	−.05	59.1	+1.1	84	27	67	35	12	51	25	53	50	79	1.28	−1.7	5	7,075	ne.	43	sw.	28	4	11	13	6.6	0.0	0.0
Florida Peninsula							70.4	+3.9										81	1.12	−0.8										4.2		
Key West	22	10	64	30.00	30.02	−.05	74.0	+3.5	85	22	79	62	2	69	15	68	67	83	1.21	−0.1	4	5,828	se.	28	nw.	6	21	5	2	2.5	0.0	0.0
Miami	25	71	164	30.03	30.06	−.05	71.6	+4.5	82	28	77	47	14	66	28	66	64	81	0.44	−1.4	8	6,540	s.	23	s.	28	8	13	7	5.3	0.0	0.0
Tampa	35	79	87	30.01	30.05	−.05	65.6	+3.7	84	26	74	43	12	57	26	59	57	80	1.72	−0.8	7	3,835	ne.	18	e.	25	4	10	14	6.4	0.0	0.0
Titusville	44	5	......	30.00	30.05	......	64.0	......	86	9	72	39	2	56	20	......	......	......	0.75	......	5	......	nw.	......	......	......	16	10	2	2.6	0.0	0.0
East Gulf States							48.4	−2.8										76	7.09	+2.3										6.8		
Atlanta	1,173	190	216	28.82	30.08	−.04	43.6	−1.7	71	25	52	20	1	35	28	39	34	73	9.21	+4.4	13	6,676	nw.	26	nw.	21	5	8	15	6.6	T.	0.0
Macon	370	78	87	29.68	30.09	−.03	48.2	−1.1	74	25	58	26	1	38	31	42	37	73	12.04	+7.6	13	3,663	nw.	26	nw.	26	6	8	14	6.6	0.0	0.0
Thomasville	273	49	58	29.76	30.06	−.06	55.2	+0.2	78	9	65	30	12	45	30	49	45	76	3.71	−0.8	11	3,241	ne.	19	sw.	27	4	8	16	7.0	0.0	0.0
Apalachicola	36	42	49	30.02	30.06	......	56.2	......	71	27	62	34	12	50	22	53	50	83	6.30	+2.4	12	5,549	n.	24	ne.	6	4	8	16	7.1	0.0	0.0
Pensacola	56	149	185	30.00	30.06	−.05	53.2	−2.0	70	27	60	31	12	46	21	49	46	80	5.18	+0.8	12	8,347	n.	38	s.	26	4	6	18	6.8	0.0	0.0
Anniston	741	9	57	29.30	30.11	−.01	43.4	−2.4	72	25	58	20	1	34	33	......	......	......	7.15	+1.7	12	3,257	nw.	18	s.	25	8	6	14	6.4	0.0	0.0
Birmingham	700	11	48	29.31	30.10	−.02	44.2	−3.8	74	25	53	19	11	36	28	39	34	73	6.33	+1.3	12	3,994	n.	27	se.	25	9	3	16	6.4	0.0	0.0
Mobile	57	125	161	29.99	30.06	−.05	51.9	−2.8	75	19	60	29	12	43	27	47	43	79	9.13	+3.8	16	6,215	n.	27	nw.	20	3	7	18	7.2	0.0	0.0
Montgomery	223	100	112	29.83	30.09	−.03	49.0	−2.6	76	27	58	26	12	40	26	44	38	71	10.34	+4.9	10	3,981	ne.	25	w.	20	6	7	15	6.8	0.0	0.0
Corinth	469	6	......	......	......	......	40.2	......	71	25	40	17	10	32	31	......	......	......	5.22	......	11	......	n.	......	......	......	3	12	13	......	T.	0.0
Meridian	375	87	95	29.67	30.08	−.03	45.8	−3.8	76	25	55	22	11	36	31	41	37	76	5.75	+0.3	14	3,435	ne.	21	s.	25	6	6	16	6.8	0.0	0.0
Vicksburg	247	65	73	29.81	30.10	.00	44.5	−7.3	80	25	52	22	10	36	36	40	35	74	3.64	−1.2	13	3,998	n.	29	s.	25	5	6	17	7.1	T.	0.0
New Orleans	53	76	84	29.99	30.05	−.04	53.8	−3.5	80	19	62	32	12	46	20	49	46	80	6.26	+2.0	13	4,583	ne.	21	nw.	5	4	5	19	7.3	0.0	0.0
West Gulf States							44.1	−7.4										79	1.58	−0.9										6.6		
Shreveport	249	77	93	29.82	30.10	+.01	42.6	−8.3	74	25	51	22	10	35	30	30	34	76	2.54	−0.8	14	3,752	se.	24	sw.	25	9	5	14	6.4	T.	0.0
Bentonville	1,303	11	44	28.70	30.12	+.02	28.7	−9.8	52	25	37	−8	10	20	37	......	......	......	2.90	......	9	......	n.	......	......	......	11	2	15	......	15.5	0.0
Fort Smith	457	79	94	29.62	30.12	+.02	32.6	−10.2	63	17	40	3	10	26	32	30	26	80	2.66	+0.1	13	4,404	e.	31	w.	25	10	2	16	6.5	11.4	0.0
Little Rock	357	136	153	29.72	30.12	+.01	36.6	−8.3	69	25	44	13	10	29	26	32	27	72	2.38	−1.5	13	4,912	n.	26	s.	25	8	6	14	6.4	6.9	0.0
Austin	605	136	148	29.40	30.05	......	46.2	−7.2	76	18	56	20	9	36	35	42	39	82	0.82	−1.5	10	5,710	n.	27	n.	8	8	7	13	6.1	0.0	0.0
Brownsville	57	53	61	29.93	29.99	......	50.2	−3.4	81	25	68	33	11	50	34	54	52	83	0.27	−0.9	5	6,646	nw.	31	s.	24	4	13	11	6.8	0.0	0.0
Corpus Christi	20	11	78	29.99	30.01	−.04	53.5	−4.9	81	25	61	27	10	46	33	51	49	86	0.06	−1.4	4	7,118	n.	29	n.	15	5	7	16	7.1	0.0	0.0
Dallas	512	220	227	29.54	30.11	......	37.7	......	69	17	44	12	9	31	28	......	......	......	1.75	−0.5	12	7,562	n.	31	w.	25	7	5	16	6.7	2.0	0.0
Fort Worth	670	106	114	29.36	30.09	+.02	39.0	−9.3	71	17	46	14	9	32	29	35	30	76	2.78	+1.0	12	5,014	nw.	24	w.	25	7	5	16	6.8	0.0	0.0
Galveston	54	106	114	29.99	30.05	−.02	51.0	−5.3	70	25	57	27	10	45	25	48	46	86	2.73	−0.1	10	6,805	n.	30	n.	8	6	5	17	6.9	0.0	0.0
Groesbeck	461	11	56	29.57	30.07	......	41.3	......	70	18	49	16	9	34	28	......	......	......	1.74	−1.1	11	6,707	n.	36	ne.	27	9	4	15	6.4	T.	0.0
Houston	138	202	314	29.90	30.05	......	49.0	−6.9	74	18	57	23	10	41	36	......	......	......	1.43	−1.8	9	7,848	nw.	33	n.	9	6	6	16	7.0	T.	0.0
Palestine	510	64	72	29.54	30.09	+.01	41.6	−9.6	69	18	50	17	9	34	30	38	35	80	1.59	−1.5	13	4,601	n.	21	s.	25	9	2	17	6.5	T.	0.0
Port Arthur	34	58	66	30.01	30.05	......	50.1	......	72	19	57	28	11	43	20	......	......	......	5.64	......	13	5,357	e.	25	nw.	8	5	5	18	7.3	0.0	0.0
San Antonio	693	119	132	29.29	30.03	−.02	50.0	−5.4	78	21	61	22	10	39	40	44	37	69	0.16	−1.5	5	4,953	ne.	24	n.	15	10	8	10	5.9	0.0	0.0
Taylor	583	55	63	29.47	30.10	+.04	43.6	−7.7	75	18	53	18	9	34	36	......	......	......	1.22	−0.9	6	5,505	n.	24	nw.	9	7	6	15	6.4	0.1	0.0

TABLE 1.—*Climatological data for Weather Bureau Stations, February, 1929*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Ohio Valley and Tennessee							31.1	-5.0										76	2.93	-0.4										6.6		
Chattanooga	762	190	215	29.27	30.11	-.02	40.8	-3.3	64	19	49	20	1	33	30	35	29	67	5.83	+1.0	13	4,188	ne.	25	nw.	22	7	7	14	6.4	T.	0.0
Knoxville	995	102	111	29.02	30.11	-.01	38.9	-3.0	61	18	46	20	2	31	31	35	31	77	5.75	+1.2	13	3,319	n.	21	sw.	19	6	8	14	6.7	1.6	0.0
Memphis	399	76	97	29.68	30.12	+.01	37.0	-7.3	68	25	43	15	10	31	22	33	27	73	3.48	-0.9	10	4,090	n.	42	w.	25	8	5	15	6.6	3.3	0.0
Nashville	546	168	191	29.54	30.14	+.02	35.4	-6.2	68	25	43	12	23	28	31	32	27	75	3.81	-0.3	13	4,769	nw.	33	s.	25	9	3	16	6.6	16.7	0.0
Lexington	989	193	230	29.04	30.16	+.05	29.2	-6.2	59	26	37	0	1	22	27				3.37	-0.2	12	6,777	sw.	36	sw.	26	9	7	12	5.8	13.5	0.0
Louisville	525	188	234	29.56	30.16	+.05	30.7	-6.5	60	26	38	4	1	23	24	27	23	76	2.16	-1.4	12	5,333	s.	25	sw.	26	7	12	9	5.8	4.7	0.0
Evansville	431	76	116	29.68	30.17	+.06	29.8	-6.5	56	25	37	0	10	23	21	26	21	71	3.26	0.0	11	4,837	n.	24	sw.	26	7	6	15	6.4	13.5	0.0
Indianapolis	822	194	230	29.21	30.13	+.03	25.6	-5.5	54	26	33	-5	1	18	25	23	18	75	1.47	-1.3	11	6,117	nw.	30	sw.	26	3	13	12	6.7	4.9	0.0
Royal Center	736	11	55	29.31	30.15		21.2		52	26	30	-14	1	12	29				0.48	-1.8	9	5,317	sw.	26	sw.	26	4	10	14	6.6	3.7	0.0
Terre Haute	575	96	129	29.49	30.14		26.7		56	26	35	-2	1	19	26	24	20	79	1.02	-1.6	10	4,994	nw.	22	s.	17	7	9	12	6.3	5.4	0.0
Cincinnati	627	11	51	29.44	30.15	+.05	27.8	-5.0	60	26	36	-5	1	20	25	25	22	83	1.58	-1.4	9	3,888	sw.	24	sw.	26	7	9	12	6.3	6.9	0.0
Columbus	822	179	222	29.22	30.14	+.05	26.2	-4.5	59	26	34	-2	1	18	28	24	21	84	3.36	+0.7	9	5,337	nw.	26	w.	27	6	11	11	6.4	10.3	0.0
Dayton	899	137	173	29.14	30.14		26.4	-5.0	58	26	34	-5	1	18	25	23	19	76	3.43	+0.7	11	4,745	sw.	28	sw.	26	4	13	11	6.7	10.1	0.0
Elkins	1,947	59	67	28.00	30.15	+.05	28.6	-3.0	59	26	38	-1	4	19	37	26	22	82	2.58	-0.5	15	3,236	w.	19	w.	19	3	6	19	7.8	12.9	T.
Parkersburg	637	77	82	29.47	30.15	+.05	30.2	-4.0	62	26	38	5	23	22	32	26	22	74	2.69	-0.4	11	2,998	sw.	20	se.	26	5	7	16	7.4	9.1	0.0
Pittsburgh	842	353	410	29.19	30.13	+.04	28.6	-3.7	58	26	35	3	20	22	20	25	21	74	2.62	0.0	9	5,976	w.	44	se.	26	2	7	19	8.0	10.0	0.5
Lower Lake Region							23.1	-1.8										80	1.58	-0.8										7.4		
Buffalo	767	247	280	29.22	30.09	+.03	22.4	-1.9	53	26	28	3	20	17	27	21	19	86	1.67	-1.3	21	9,331	w.	52	w.	27	2	9	17	7.7	15.7	T.
Canton	448	10	61	29.58	30.09		14.9	-3.1	45	27	24	-18	20	6	33				1.67	-0.6	16	4,652	w.	32	w.	18	8	9	11	5.9	22.1	7.0
Ithaca	836	5	100	29.15	30.10		22.6		46	18	30	-7	23	16	38	21	18	81	1.65	-0.3	15	5,520	nw.	42	se.	26	4	7	17	7.7	10.2	1.6
Oswego	335	76	91	29.72	30.10	+.04	23.6	-0.3	43	27	29	4	21	18	27	22	19	83	2.26	-0.4	15	6,111	se.	32	se.	26	1	4	23	8.6	37.9	10.5
Rochester	523	86	102	29.52	30.11	+.05	24.4	-0.2	49	26	30	5	20	19	31	22	18	75	1.46	-1.2	17	5,579	w.	26	w.	27	2	6	20	8.0	14.1	2.0
Syracuse	596	65	79	29.45	30.12	+.05	24.3	+0.5	46	18	30	4	20	18	27				1.98	-0.7	15	4,315	w.	20	se.	26	1	10	17	8.0	16.6	2.5
Erie	714	130	166	29.31	30.11	+.04	24.8	-2.1	55	26	31	-1	20	19	24	23	18	74	1.36	-1.2	13	7,603	sw.	37	se.	26	4	6	18	7.5	9.8	0.0
Cleveland	762	190	201	29.27	30.12	+.05	25.2	-2.2	57	26	31	1	20	19	23	23	19	78	1.98	-0.5	11	6,282	w.	31	se.	26	1	6	21	7.9	6.8	0.0
Sandusky	620	5	67	29.42	30.13	+.06	24.2	-3.2	58	26	32	-7	20	16	25				1.79	-0.4	11	4,890	sw.	30	sw.	26	3	8	17	7.4	14.6	0.0
Toledo	628	208	243	29.42	30.13	+.06	24.2	-3.1	55	26	31	-1	20	17	23	21	17	74	1.08	-1.0	8	7,007	sw.	40	sw.	26	6	8	14	6.6	7.5	0.0
Fort Wayne	856	113	124	29.16	30.12		23.1	-2.7	51	26	30	-2	20	16	29	21	18	82	0.73	-1.6	9	4,786	sw.	29	sw.	26	1	15	12	6.9	6.2	0.0
Detroit	730	218	258	29.29	30.12	+.06	23.2	-2.1	51	26	29	-1	20	17	22	21	19	85	1.36	-0.8	12	5,964	w.	32	w.	26	2	12	14	7.2	10.8	0.0
Upper Lake Region							14.9	-4.1										85	0.88	-1.0										6.4		
Alpena	609	13	92	29.41	30.11	+.08	14.6	-3.4	42	26	23	-21	20	6	35	12	9	83	0.91	-0.8	11	5,391	nw.	27	sw.	26	8	9	11	5.7	9.1	3.0
Escanaba	612	54	60	29.42	30.13	+.07	10.6	-4.8	35	26	20	-17	20	1	30	9	6	84	0.86	-0.6	10	4,695	n.	27	ne.	26	7	8	13	5.0	7.2	16.5
Grand Haven	632	54	89	29.39	30.12	+.07	19.7	-4.5	45	26	26	-3	20	13	26	18	16	87	0.72	-1.5	15	5,992	e.	30	sw.	26	3	8	17	7.7	11.2	5.8
Grand Rapids	707	70	87	29.31	30.12	+.07	20.6	-3.1	45	26	27	-9	20	14	29	19	15	79	0.66	-1.6	12	3,578	w.	18	w.	26	3	11	14	7.3	8.2	3.5
Houghton	668	64	99	29.35	30.12	+.07	7.4	-6.3	38	27	17	-21	13	-2	36				1.19	-0.6	7	4,498	w.	27	w.	15	6	10	12	6.5	11.5	21.6
Lansing	878	6	49	29.12	30.11		19.4	-3.5	43	26	27	-22	20	12	36	17	16	92	0.96	-0.9	16	3,336	w.	19	w.	26	4	14	10	6.4	8.0	2.2
Ludington	637	60	66	29.36	30.09		18.6		42	26	24	-2	20	13	20	18	16	87	1.17	-0.8	17	5,403	e.	32	s.	26	4	6	18	7.4	17.8	10.3
Marquette	734	77	111	29.27	30.12	+.07	12.5	-3.8	36	27	20	-14	19	5	22	10	8	85	1.16	-0.7	13	4,727	nw.	29	sw.	20	5	8	15	7.0	11.3	23.8
Port Huron	638	70	120	29.38	30.11	+.06	20.9	-1.8	48	26	27	-10	20	14	26	19	16	85	0.69	-1.2	10	5,746	nw.	29	w.	27	7	10	11	5.8	9.6	T.
Sault Sainte Marie	614	11	52	29.38	30.12	+.09	9.9	-2.7	36	26	18	-19	19	1	32	7	6	90	0.57	-1.4	11	3,966	nw.	29	nw.	18	4	12	12	6.2	4.8	11.0
Chicago	673	7	131	29.37	30.13	+.05	21.6	-4.7	47	26	28	-2	1	15	25	19	15	78	0.54	-1.6	11	5,653	w.	33	sw.	26	5	8	15	6.7	8.6	0.0
Green Bay	617	109	141	29.42	30.12	+.06	10.8	-6.6	37	26	20	-24	20	2	39	10	8	89	1.58	0.0	10	5,179	s.	29	sw.	26	8	6	14	6.3	16.0	18.1
Milwaukee	681	125	221	29.34	30.12	+.06	19.0	-3.8	42	27	26	-9	20	12	28	17	12	77	0.96	-0.9	11	7,687	nw.	37	w.	26	9	6	13	6.3	11.2	2.8
Duluth	1,133	5	47	28.83	30.12	+.04	6.8	-4.6	34	26	16	-26	19	-2	29	5	2	85	0.37	-0.7	8	6,829	nw.	34	nw.	21	9	8	11	5.2	4.2	11.0
North Dakota							3.4	-4.6										86	0.34	-0.2										6.1		
Moorhead	940	50	58	29.08	30.17	+.06	3.6	-4.5	33	26	13	-29	19	-6	35	3	1	90	0.47	-0.2	11	4,552	s.	20	s.	20	5	8	15	7.0	6.5	6.9
Bismarck	1,674	8	57	28.25	30.15	+.03	4.6	-5.7	33	23	16	-43	19	-6	44	3	1	84	0.32	-0.1	7	4,231	nw.	24	nw.	13	9	12	7	5.2	3.1	2.2
Devils Lake	1,478	11	44	28.46	30.14	+.03	1.4	-3.7	33	25	11	-29	19	-8	30	0	-2	90	0.12	-0.4	7	4,887	w.	22	nw.	20	7	9	12	5.7	1.9	2.0
Ellendale	1,457	10	56	28.49	30.15		3.9		31	20	14	-36	19	-6	36				0.32	-0.3	10	7,331	nw.	35	n.	16	5	10	13	6.6	4.1	3.5
Grand Forks	833	12	67				1.6		33	27	12	-28	19	-9	35	0			0.18		6		nw.				9	10	9		2.6	9.7
Williston	1,878	41	48	28.04	30.14	+.03	3.8	-4.3	33	25	14	-38	19	-6	58	3	0	82	0.46	0.0	6	3,961	w.	25	e.	15	9	7	12	5.8	5.1	6.2
Upper Mississippi Valley							17.9	-6.7										81	1.31	-0.3										6.6		
Minneapolis	918	102	208	29.09	30.13		10.5	-5.4	35	26	18	-20	19	3	37				1.05	+0.1	12	6,009	w.	26	s.	20	2	7	19	7.9	11.7	13.8
St. Paul	837	236	261	29.18	30.14	+.05	9.6	-6.2	34	26	17	-24	19	2	38				0.95	0.0	12	5,707	se.	27	nw.	17	2	8	18	7.7	12.2	14.0
La Crosse	714	11	48	29.33	30.15	+.07	11.6	-7.6	38	27	21	-27	20	2	42	10	6	80	1.18	+0.1	9	2,479	s.	15	s.	20	5	9	14	6.7	12.2	26.2
Madison	974	70	78	29.03	30.15	+.08	12.8	-6.3	38	27	20	-21	20	5	34	11	9	85	1.48	0.0	7	4,300	nw.	27	sw.	26	8	7	13	6.3	9.9	17.1
Wausau	1,247	4	64		30.12		9.0		35	27	18	-27	20	0	37				1.30	+0.1	9	2,981	n.	18	ne.	26	7	9	12		12.7	14.0
Charles City	1,015	10	51	29.02	30.16	+.06	9.1	-8.0	32	23	19	-28	20	-1	43	9	7	90	1.73	+0.6	10	3,508	se.	19	se.	20	8	7	13	6.5	20.7	26.5
Davenport	606	71	79	29.45	30.15	+.05	18.1	-6.8	43	23	26	-11	20	10	34	16	13	85	0.81	-0.8	9	5,589	w.	30	sw.	26	8	9	11	6.2	5.4	0.2
Des Moines	861	84	97	29.20	30.16	+.05	15.2	-8.5	43	23	24	-13	9	7	30	14	12	88	2.06	+0.9	15	3,974	n.	19	sw.	22	8	7	13	6.2	19.1	9.8
Dubuque	700	81	96	29.35	30.15	+.06	14.0	-8.2	39	27	23	-24	20	5	40	13	9	80	1.00	-0.4	9	3,306	nw.	19	nw.	18	8	2	18	7.0	8.0	8.8
Keokuk	614	64	78	29.46	30.17	+.06	21.4	-6.9	52	23	30	-6	9	13	39	18	13	74	0.97	-0.6	11	4,299	e.	24	sw.	26	7	7	14	6.5	5.8	T.
Cairo	358	87	98	29.75	30.15	+.03	31.4	-7.1	60	25	38	5	10	24	22	28	24	76	4.20	+1.1	8	5,348	n.	27	sw.	26	7	8	13	6.3	11.5	0.0
Peoria	600	11	45	29.46	30.16	+.06	21.2	-4.7	50	24	30	-9	1	13	28	19	16	84	0.58	-1.4	9	4,000	nw.	23	w.	26	9	8	11	5.5	4.1	0.0
Springfield, Ill	636	154	191	29.43	30.14	+.04	23.8	-5.7	53	24	32	-4	9	16	27	21	17	79	0.65	-1.7	8	6,717	nw.	31	s.	16	6	6	16	6.8	3.6	0.0
Hannibal	534	74	109	29.56	30.16	+.05	23.4	-6.3	55	17	32	-6	10	15	38				0.84	-1.0	9	5,041	sw.	28	sw.	25	7	7	14	6.4	3.9	0.0
St. Louis	568	265	303	29.51	30.14	+.03	28.8	-5.7	58	24	37	4	9	21	28	25	19	72	0.88	-1.7	10	6,122	nw.	33	sw.	23	8	8	12	6.1	5.7	0.0
Missouri Valley							18.8	-7.1										81	1.15	0.0										6.2		
Columbia, Mo	784	6	84	29.29	30.16	+.05	25.4	-6.3	56	17	34	-5	10	17	36				1.03	-1.0	9	4,530	e.	23	sw.	16	7	6	15	6.4	3.5	0.0
Kansas City	963	161	181	29.06	30.15	+.04	24.0	-7.2	52	23	32	-5	9	16	40	21	16	75	1.79	0.0	14	5,958	n.	30	n.	17	6	11	11	6.0	10.2	0.0
St. Joseph	967	11	49	29.06	30.14		21.8		50	23	30	-10	9	14	37	19	15	80	1.57	+0.2	13	4,762	nw.	24	nw.	17	10	7	11	5.2	7.7	T.
Springfield, Mo	1,324	98	104	28.67	30.13	+.02	26.5	-8.7	55	17	34	-3	10	19	28	24	22	85	1.55	-0.8	9	5,410	nw.	24	s.	26	10	2	16	6.1	9.8	0.0
Iola	984	11	50	29.06	30.16	+.06	26.8	-6.4	55	23	36	-4	10	18	35				0.77	-0.9	5	3,520	n.	19	s.	23	10	5	13	6.1	4.4	0.0
Topeka	987	92	107				23.4	-7.6	53	23	32	-7	9	15	37				1.26	-0.2	11	5,268	n.	27	n.	17	7	11	10	5.6	6.5	0.0
Lincoln	1,180	11	81	28.82	30.15	+.05	19.2	-6.9	51	23	28	-13	9	11	40	16	12	77	1.06	+0.1	8	5,591	n.	28	nw.	10	7	7	14	6.3	11.3	0.6
Omaha	1,105	115	122	28.91	30.16	+.05	18.6	-6.9	49	23	27	-11	9	10	38	16	12	78	2.20	+1.3	10	5,136	nw.	26	nw.	17	10	5	13	5.8	21.9	5.9
Valentine	2,598	47	54	27.29	30.15	+.06	14.2	-7.2	44	23	26	-22	8	2	42	12	9	83	1.03	+0.5	11	4,929	w.	28	nw.	10	4	19	5	5.6	14.2	0.4
Sioux City	1,135	94	164	28.88	30.17	+.05	13.5	-7.5	43	23	23	-15	9	4	41	13	11	86	1.00	+0.2	12	6,538	nw.	32	nw.	16	6	10	12	6.5	9.8	3.1
Huron	1,306	59	74	28.69	30.18	+.06	8.2	-6.1	36	20	19	-29	19	-2	38	8	5	82	0.51	0.0	9	5,305	nw.	24	nw.	16	4	8	16	7.2	6.9	6.0
Pierre	1,572	70	75		30.18	+.07	12.0	-6.6	40	22	23	-22	19	1	39			80	0.59	+0.2	10	4,721	nw.	25	nw.	16	6	9	13		5.9	0.5
Yankton	1,233	49	57	28.75	30.14	+.02	13.2	-7.7	39	27	23	-18	8	4	45				0.63	-0.2	11	4,691	nw.	25	nw.	16	4	9	15	7.1	7.0	1.7

TABLE 1.—*Climatological data for Weather Bureau stations, February, 1929*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	° F.	° F.	° F.		° F.	° F.		° F.	° F.	° F.	° F.	%	In.	In.		Miles								0–10	In.	In.
Northern Slope							13.8	-8.0										78	0.68	0.0										6.2		
Billings	3,140	5					14.9		45	23	27	-30	7	3	43				0.63		9		sw.				12	6	10		10.6	6.8
Havre	2,505	11	44	27.39	30.18	+0.11	8.2	-5.4	37	18	19	-36	18	-3	61	8	6	86	0.23	-0.3	5	4,497	sw.	31	sw.	19	5	12	11	6.2	5.1	2.8
Helena	4,110	87	112	25.77	30.16	+.05	16.0	-7.0	40	15	25	-20	7	8	35	14	10	76	1.00	+0.4	10	4,307	sw.	31	sw.	15	2	9	17	7.5	15.4	8.7
Kalispell	2,973	48	56	26.96	30.18	+.10	14.6	-8.7	38	24	24	-17	7	5	25	13	11	84	1.02	-0.1	11	2,453	nw.	19	ne.	16	6	12	10	6.0	10.5	20.0
Miles City	2,371	48	55	27.50	30.20	+.11	8.8	-8.0	39	15	20	-33	7	-2	55	8	5	85	0.38	-0.1	10	3,409	s.	24	nw.	15	8	4	16	6.3	5.0	7.0
Rapid City	3,259	50	58	26.56	30.17	+.09	14.9	-8.5	44	23	25	-20	6	5	39	12	6	69	0.49	0.0	7	4,199	n.	27	n.	9	6	15	7	5.6	5.7	0.5
Cheyenne	6,088	84	101	23.84	30.07	+.04	17.2	-10.1	47	1	27	-15	8	7	39	14	8	66	0.85	+0.2	12	7,625	w.	44	w.	20	8	5	15	6.6	10.6	1.5
Lander	5,372	60	68	24.53	30.14	+.06	12.2	-10.3	40	16	24	-23	7	0	42	10	8	87	0.68	0.0	6	2,027	e.	23	nw.	16	9	13	6	5.0	8.5	8.0
Sheridan	3,790	10	47	26.05	30.14		13.2		44	3	26	-32	7	0	49	12	7	72	0.91	+0.2	12	3,054	nw.	24	nw.	27	6	9	13	6.4	13.5	6.0
Yellowstone Park	6,241	11	48	23.76	30.15	+.05	13.7	-5.9	39	2	23	-27	7	5	31	11	7	78	0.77	-0.6	16	4,321	sw.	26	sw.	20	4	7	17	7.2	8.3	13.9
North Platte	2,821	11	51	27.06	30.12	+.05	18.7	-7.9	51	4	30	-15	9	8	36	16	12	77	0.44	-0.1	6	4,387	n.	20	nw.	20	8	11	9	5.3	4.5	T.
Middle Slope							25.8	-8.0										74	0.85	-0.1										5.5		
Denver	5,292	106	113	24.61	30.06	+.05	23.6	-9.1	53	3	34	-9	8	13	40	18	11	64	0.78	+0.2	10	4,503	s.	25	w.	20	12	10	6	4.7	15.2	0.8
Pueblo	4,685	80	86	25.19	30.02	+.02	25.8	-7.1	60	23	40	-13	8	12	47	21	13	64	0.78	+0.3	8	3,943	nw.	33	w.	16	11	7	10	4.9	10.2	0.1
Concordia	1,392	50	58	28.62	30.17	+.08	22.6	-7.2	58	23	32	-10	9	14	42	19	15	78	0.94	+0.1	11	4,532	n.	22	nw.	10	11	4	13	5.9	8.8	0.3
Dodge City	2,509	11	51	27.43	30.15	+.09	24.4	-8.8	56	23	35	-12	9	14	40	20	17	82	0.72	0.0	5	5,143	n.	22	se.	1	15	3	10	4.5	9.1	T.
Wichita	1,358	139	158	28.63	30.12	+.04	27.4	-7.0	55	17	35	-2	9	20	32	24	21	79	0.65	-0.6	9	6,364	s.	40	sw.	23	11	7	10	5.4	5.5	0.0
Broken Arrow	765	11	56	29.29	30.14		29.2		60	17	37	-3	10	21	35				1.13	-0.2	9	6,497	n.	29	s.	23	10	2	16	6.4	11.0	0.0
Oklahoma City	1,214	10	47	28.79	30.12	+.05	30.8	-8.8	58	17	39	0	9	23	35	27	24	80	0.93	-0.2	9	5,610	n.	23	s.	24	9	3	16	6.8	4.9	0.0
Southern Slope							39.4	-6.6										66	0.60	-0.1										5.3		
Abilene	1,738	10	52	28.21	30.07	+.02	39.0	-8.2	77	17	49	10	9	29	41	33	28	74	1.40	+0.4	8	5,374	n.	27	s.	24	8	9	11	6.7	0.5	0.0
Amarillo	3,676	10	49	26.21	30.05	+.03	30.6	-7.5	66	24	41	2	9	20	38	24	18	66	0.34	-0.4	4	5,202	n.	22	ne.	21	11	5	12	5.5	5.6	0.0
Del Rio	944	64	71	29.00	30.00	.00	50.6	-5.4	77	18	62	21	9	40	42	43	35	63	0.18	-0.4	5	5,295	se.	31	nw.	25	11	9	8	5.2	0.0	0.0
Roswell	3,566	75	85	26.30	29.99	+.01	37.4	-5.1	60	18	52	0	10	23	47	30	22	59	0.46	-0.1	4	4,177	s.	31	nw.	20	15	7	6	3.8	5.2	0.0
Southern Plateau							41.3	-3.5										44	0.41	-0.2										3.2		
El Paso	3,778	152	175	26.12	29.94	-.01	46.8	-2.2	70	18	58	18	9	35	35	36	21	40	0.20	-0.1	2	7,876	w.	44	w.	24	19	6	3	3.0	1.1	0.0
Santa Fe	7,013	38	53	23.09	29.96	-.02	27.2	-5.9	49	23	37	-3	9	17	29	22	13	58	0.97	+0.2	6	3,621	n.	20	n.	20	11	9	8	4.5	11.4	1.0
Flagstaff	6,907	10	59	23.22	29.94	-.06	24.4	-6.4	51	22	38	-21	9	11	45				1.20		5		nw.		ne.	26	15	6	7		11.0	T.
Phoenix	1,108	10	107	28.80	29.97	-.02	53.0	-2.1	80	23	66	28	10	40	40	42	28	44	0.28	-0.5	4	3,699	e.	26	nw.	24	14	8	6	3.6	0.0	0.0
Yuma	141	9	54	29.86	30.01	+.01	55.0	-3.6	85	23	70	33	14	40	43	43	23	33	T.	-0.4	0	3,919	n.	40	nw.	15	21	7	0	1.7	0.0	0.0
Independence	3,957	6	27	25.97	30.06	.00	41.4	-0.8	68	27	55	15	9	27	42	30			0.49	-0.3	3		nw.				18	7	3		0.0	0.0
Middle Plateau							27.1	-6.3										68	0.88	-0.2										4.7		
Reno	4,532	74	81	25.49	30.14	+.06	31.9	-3.7	59	22	44	-6	8	20	36	27	20	61	1.08	-0.1	6	3,113	w.	26	se.	3	16	6	6	3.6	9.2	0.0
Tonopah	6,090	12	20				28.4		49	22	36	-1	8	21	25	25	18	65	0.10		4		nw.									
Winnemucca	4,344	18	56	25.66	30.16	+.07	29.2	-4.3	54	22	42	0	8	17	40	25	20	70	0.58	-0.3	7	4,382	sw.	21	nw.	25	11	15	2	4.0	0.5	0.0
Modena	5,473	10	43	24.55	30.04	.00	23.8	-7.2	52	22	36	-24	9	11	53	21	15	69	0.59	-0.4	6	5,348	sw.	34	nw.	27	10	9	9	4.6	8.9	0.0
Salt Lake City	4,360	163	203	25.61	30.10	+.02	27.2	-6.6	50	2	34	3	9	21	21	24	18	68	1.34	-0.2	10	3,853	nw.	30	ne.	7	9	5	14	6.0	13.2	1.9
Grand Junction	4,602	60	68	25.34	30.02	-.02	23.3	-9.7	45	3	33	-12	10	13	35	20	16	74	0.79	+0.2	8	2,497	nw.	18	nw.	5	11	8	9	5.3	8.5	0.0
Northern Plateau							22.3	-10.7										75	0.50	-1.0										6.0		
Baker	3,471	48	53	26.52	30.24	+.12	20.2	-8.8	42	28	30	-15	7	10	31	19	15	75	0.15	-1.1	5	3,753	se.	19	nw.	25	8	12	8	5.4	2.2	5.6
Boise	2,739	78	86	27.28	30.25	+.13	25.4	-9.4	47	3	34	-1	7	17	26	23	19	76	0.63	-0.8	8	2,510	nw.	19	n.	25	7	9	12	6.2	3.8	0.0
Lewiston	757	40	48	29.41	30.27	+.16	21.4	-15.6	50	27	29	-15	8	13	25				1.00	-0.3	10	1,742	e.	16	nw.	27	7	6	15	6.3	8.8	T.
Pocatello	4,477	60	68	25.46	30.15	+.05	20.9	-8.0	44	2	28	-12	9	14	24	18	14	74	0.74	-0.5	9	5,282	se.	36	sw.	20	5	12	11	6.1	9.3	T.
Spokane	1,929	101	110	28.10	30.24	+.15	21.4	-9.9	44	25	31	-12	8	12	30	20	15	75	0.09	-1.7	3	2,617	sw.	18	sw.	19	9	10	9	5.6	2.8	0.5
Walla Walla	991	57	65	29.16	30.28	+.17	24.7	-12.4	49	24	31	-10	8	18	29	22	18	75	0.39	-1.4	8	2,353	s.	21	w.	25	8	7	13	6.4	5.9	0.0
North Pacific Coast Region							37.8	-4.0										75	0.97	-4.0										5.8		
North Head	211	11	56	30.01	30.24	+.18	39.8	-3.2	48	23	44	26	7	35	18	38	36	86	1.25	-6.2	12	6,338	n.	42	s.	22	10	6	12	5.4	0.0	0.0
Port Angeles	29	8	53		30.24		36.0		51	19	43	19	6	29	21				0.91	-2.1	7	3,804	sw.	28	nw.	19	6	6	16		4.0	0.0
Seattle	125	215	250	30.08	30.22	+.16	36.2	-4.9	50	20	42	18	7	31	21	35	32	83	1.10	-2.8	9	4,184	ne.	38	sw.	19	8	7	13	6.5	7.0	0.0
Tacoma	194	172	201	30.01	30.22	+.16	35.6	-5.0	52	25	42	15	8	29	23				0.74	-4.0	10	4,664	s.	31	ne.	6	4	10	14	7.1	5.0	0.0
Tatoosh Island	86	9	53	30.10	30.20	+.20	40.5	-0.5	46	14	43	32	1	38	9	38	35	84	1.64	-7.8	10	8,949	e.	42	nw.	24	9	7	12	5.3	T.	0.0
Yakima	1,076	58	67	29.06	30.27		23.4		51	28	34	-11	9	13	35	21	15	71	0.01	-1.0	1	2,123	se.	22	nw.	25	7	12	9	5.4	0.2	T.
Medford	1,425	4	80	28.64	30.18		38.3		63	28	52	13	7	25	38	33	26	65	0.24		6		se.	22	se.	8	14	6	8	4.4	T.	0.0
Portland, Oreg.	153	68	106	30.09	30.26	+.18	35.6	-6.5	52	20	42	16	9	29	22	33	26	67	0.97	-4.4	8	3,343	e.	24	e.	6	7	5	16	6.6	0.3	0.0
Roseburg	510	75	99	29.66	30.23	+.13	39.4	-4.0	60	21	50	16	7	29	35	36	31	72	1.11	-3.4	8	1,898	nw.	25	n.	25	7	14	7	5.4	T.	0.0
Middle Pacific Coast Region							48.5	-1.4										66	1.69	-2.2										3.5		
Eureka	62	73	89	30.12	30.19	+.08	44.8	-2.4	60	3	51	29	7	38	22	42	39	78	2.06	-4.4	6	3,705	n.	26	n.	6	11	6	11	4.9	0.0	0.0
Red Bluff	330	54	58	29.75	30.12	+.01	48.3	-1.1	74	28	60	26	11	36	37	40	28	49	2.21	-1.7	5	3,979	nw.	28	se.	3	16	8	4	3.6	0.0	0.0
Sacramento	69	106	117	30.02	30.10	+.01	49.0	-1.1	74	28	59	28	8	39	32	45	30	70	1.44	-1.6	6	4,855	nw.	28	se.	3	21	4	3	2.3	0.0	0.0
San Francisco	155	208	243	29.94	30.11	+.01	51.8	-0.4	72	28	59	35	7	45	25	45	30	66	2.14	-1.7	5	4,844	w.	34	w.	25	14	8	6	3.6	0.0	0.0
San Jose	141	12	110	29.96	30.11		48.8	-1.8	72	28	61	26	9	37	34				0.61	-1.8	5	3,846	nw.	26	nw.	23	18	4	6	3.0	0.0	0.0
South Pacific Coast Region							52.3	-1.6										66	1.30	-0.9										3.2		
Fresno	327	89	98	29.75	30.11	+.03	49.3	-1.8	69	22	60	29	7	39	27	43	35	62	0.62	-0.8	3	3,288	nw.	28	nw.	26	20	6	2	2.3	0.0	0.0
Los Angeles	338	159	191	29.70	30.07	+.01	54.4	-1.1	79	22	62	38	9	46	29	46	38	59	2.15	-0.9	6	3,570	ne.	24	nw.	26	17	6	5	3.3	0.0	0.0
San Diego	87	62	70	29.97	30.07	+.01	53.2	-1.9	72	22	61	38	9	46	26	49	45	77	1.14	-0.9	6	3,605	e.	25	s.	1	15	5	8	4.1	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.93	30.02		75.0	+0.1	85	5	81	66	5	69	19				1.30	-1.2	16	7,628	e.	31	e.	27	8	19	1	4.4	0.0	0.0
Panama Canal																																
Balboa Heights	118	7	97	[1]29.75	[1]29.83	-.03	80.3	0.0	92	9	90	68	7	71	22	71	70	[3]73	0.02	-0.8	1	6,342	nw.	30	n	23	19	9	0	3.1	0.0	0.0
Cristobal	38	7	97	[1]29.83	[1]29.86	-.03	81.4	+0.6	88	28	87	70	8	76	17	73	71	[3]75	0.56	-1.0	9	9,230	n.	28	n.	12	9	19	0	3.9	0.0	0.0
Alaska																																
Juneau	80	11	50	30.01	30.10		31.1		42	28	34	11	2	28	11	30	28	86	7.24		22	3,669	se.	24	e.	23	2	3	23	8.6	21.9	T.
Hawaiian Islands																																
Honolulu	38	86	100	[1]29.97	[1]30.01		71.6		80	26	76	61	11	67	16	64	61	71	2.43	-1.3	12	5,420	e.	25	e.	17	9	12	7	5.1	0.0	0.0

[1] Pressure not reduced to mean of 24 hours.

[3] Observations taken bihourly.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, February, 1929*

Station	Altitude above mean sea level, Jan. 1, 1919	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Mean maximum	Temperature of the air: Mean minimum	Temperature of the air: Highest	Temperature of the air: Lowest	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Total snowfall
	Feet	*Inches*	*Inches*	*Inches*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*Inches*	*Inches*	*Inches*
Cape Race, N. F.	99				23.0		29.4	16.6	39	3	3.78		17.1
Sydney, C. B. I.	48	29.98	30.03	+0.11	21.0	+1.7	29.9	12.2	43	−5	3.89	−0.20	16.5
Halifax, N. S.	88	29.95	30.06	+.11	24.9	+2.5	33.1	16.8	47	0	2.57	−2.59	8.6
Yarmouth, N. S.	65	29.91	29.98	−.01	27.2	+1.4	33.2	21.2	45	12	4.61	+0.44	26.7
Charlottetown, P. E. I.	38	29.94	29.98	+.03	19.9	+2.3	25.3	14.4	39	−5	2.93	−0.13	21.6
Chatham, N. B.	28	29.94	29.98	+.02	13.6	+1.1	25.6	1.7	38	−27	1.30	−1.86	13.0
Father Point, Que.	20												
Quebec, Que.	296	29.75	30.10	+.11	15.2	+3.4	21.6	8.9	39	−11	2.10	−1.17	20.3
Doucet, Que.	1,236				1.3		14.2	−11.5	32	−47	1.60		16.0
Montreal, Que.	187	29.86	30.08	+.06	17.2	+2.7	23.3	11.2	41	−5	2.19	−0.88	21.5
Ottawa, Ont.	236	29.83	30.12	+.10	15.3	+3.6	24.8	5.9	40	−13	1.37	−1.32	12.9
Kingston, Ont.	285												
Toronto, Ont.	379	29.68	30.11	+.07	21.9	+0.4	28.1	15.7	43	−3	1.49	−1.12	13.3
Cochrane, Ont.	930				2.7		12.4	−7.0	28	−35	0.74		7.4
White River, Ont.	1,244												
London, Ont.	808				19.9		27.3	12.5	45	−20	3.93		35.3
Southampton, Ont.	656	29.35	30.10	+.08	15.5	−4.4	23.5	7.6	42	−7	2.78	−0.12	26.2
Parry Sound, Ont.	688	29.37	30.11	+.10	11.8	−2.5	20.5	3.2	38	−22	1.97	−0.95	17.6
Port Arthur, Ont.	644	29.37	30.12	+.07	6.1	−0.3	15.4	−3.1	33	−24	0.36	−0.54	3.6
Winnipeg, Man.	760												
Minnedosa, Man.	1,690	28.18	30.13	+.04	−2.1	+0.6	7.7	−11.8	29	−34	0.14	−0.47	1.4
Le Pas, Man.	860				−3.5		8.4	−15.3	49	−34	0.53		5.3
Qu'Appelle, Sask.	2,115	27.71	30.11	+.03	0.2	+0.8	10.0	−9.6	34	−35	0.58	−0.15	5.8
Moose Jaw, Sask.	1,759				2.9		13.0	−7.3	38	−36	0.80		8.0
Swift Current, Sask.	2,392	27.41	30.10	+.03	3.1	−4.9	14.2	−7.9	35	−38	0.54	−0.20	5.4
Medicine Hat, Alb.	2,144												
Calgary, Alb.	3,428												
Banff, Alb.	4,521												
Prince Albert, Sask.	1,450	28.47	30.16	+.07	−1.2	+1.8	9.5	−12.0	41	−41	0.56	−0.13	5.6
Battleford, Sask.	1,592	28.27	30.13	+.04	1.6	+1.5	11.5	−8.2	38	−35	0.42	+0.05	4.2
Edmonton, Alb.	2,150												
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.95	30.21	+.21	37.5	−2.0	41.9	33.1	49	24	1.03	−3.07	T.
Barkerville, B. C.	4,180												
Estevan Point, B. C.	20												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151												

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Station	Altitude	Station pressure	Sea level pressure	Pressure departure	Mean	Departure	Mean max.	Mean min.	Highest	Lowest	Total	Departure	Total snowfall
White River, Ont.	1,244	28.55	29.96	−.05	−8.6	−8.2	5.6	−22.8	20	−50	2.05	+0.36	20.5
Southampton, Ont.	656	29.22	29.96	−.07	19.0	−1.4	25.3	12.8	42	−5	4.94	+0.89	43.6
Winnipeg, Man.	760	29.29	30.20	+.09	−10.0	−3.2	−2.5	−17.5	17	−30	0.49	−0.39	4.9
Minnedosa, Man.	1,690	28.20	30.17	+.07	−11.9	−4.7	−1.5	−22.4	12	−40	0.90	+0.10	9.0
Le Pas, Man.	860				−16.1		−7.8	−24.3	10	−38	0.15		1.5
Swift Current, Sask.	2,392	27.43	30.14	+.05	−3.2	−6.3	7.4	−13.8	37	−45	1.81	+1.17	17.4
Medicine Hat, Alb.	2,144	27.71	30.10	+.03	2.8	−2.7	12.9	−7.2	46	−43	0.22	−0.35	2.2
Calgary, Alb.	3,428	26.37	30.17	+.14	6.2	−2.2	16.3	−3.8	54	−45	0.47	−0.06	4.7
Banff, Alb.	4,521	25.29	30.15	+.15	4.3	−7.8	13.3	−4.6	43	−50	0.34	−0.85	3.4
Prince Albert, Sask.	1,450	28.54	30.26	+.17	−14.7	−6.3	−3.6	−25.7	22	−50	0.41	−0.56	4.1
Battleford, Sask.	1,592	28.34	30.22	+.14	−9.1	−3.2	1.1	−19.2	39	−45	0.31	−0.09	3.1

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Chart I. Departure (°F.) of the Mean Temperature from the Normal, February, 1929

Chart I. Departure (°F.) of the Mean Temperature from the Normal, February, 1929

Chart II. Tracks of Centers of Anticyclones, February, 1929. (Inset) Departure of Monthly Mean Pressure from Normal
(Plotted by Arthur J. Haidle)

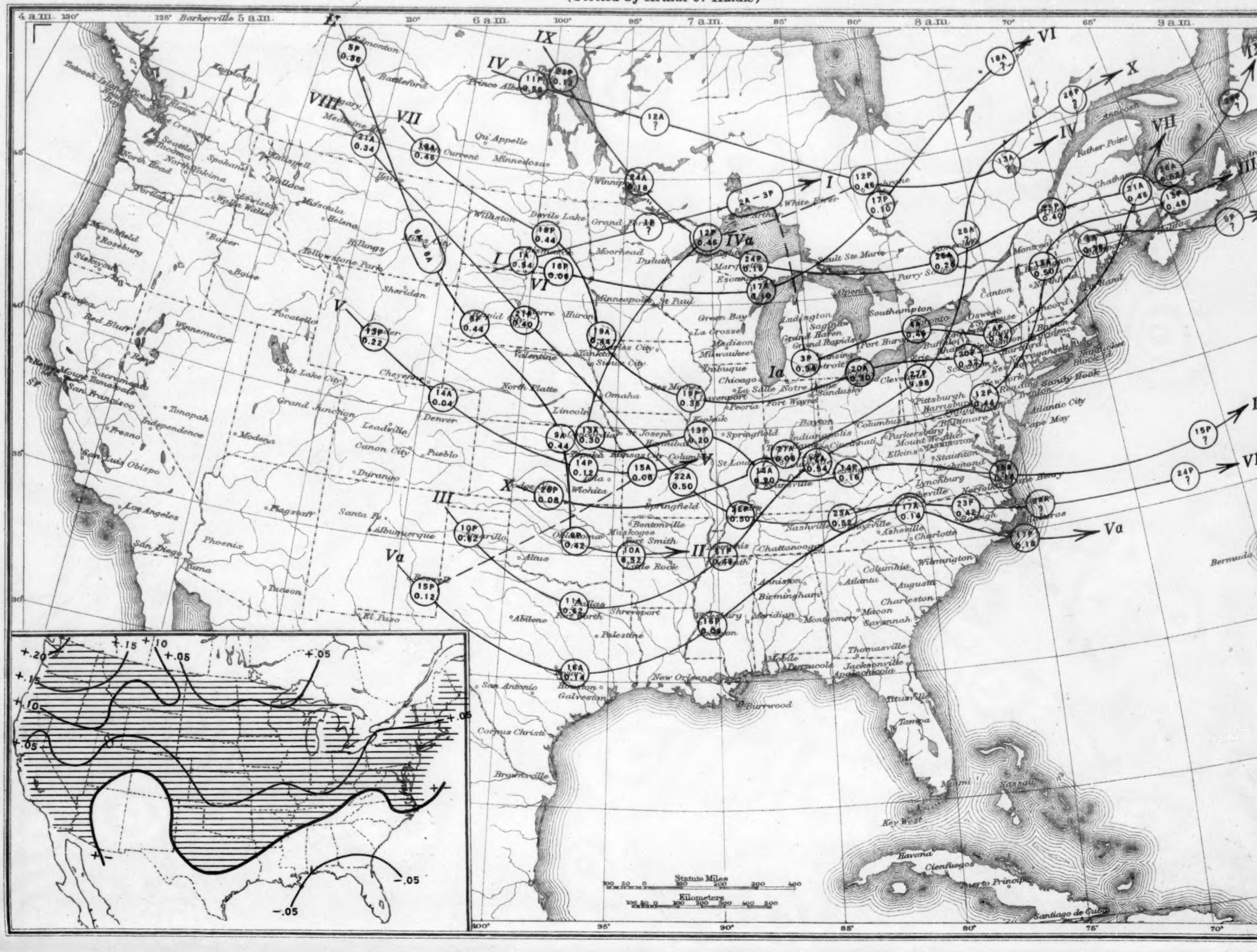

Chart III. Tracks of Centers of Cyclones, February, 1929. (Inset) Change in Mean Pressure from Preceding Month
(Plotted by Arthur J. Haidle)

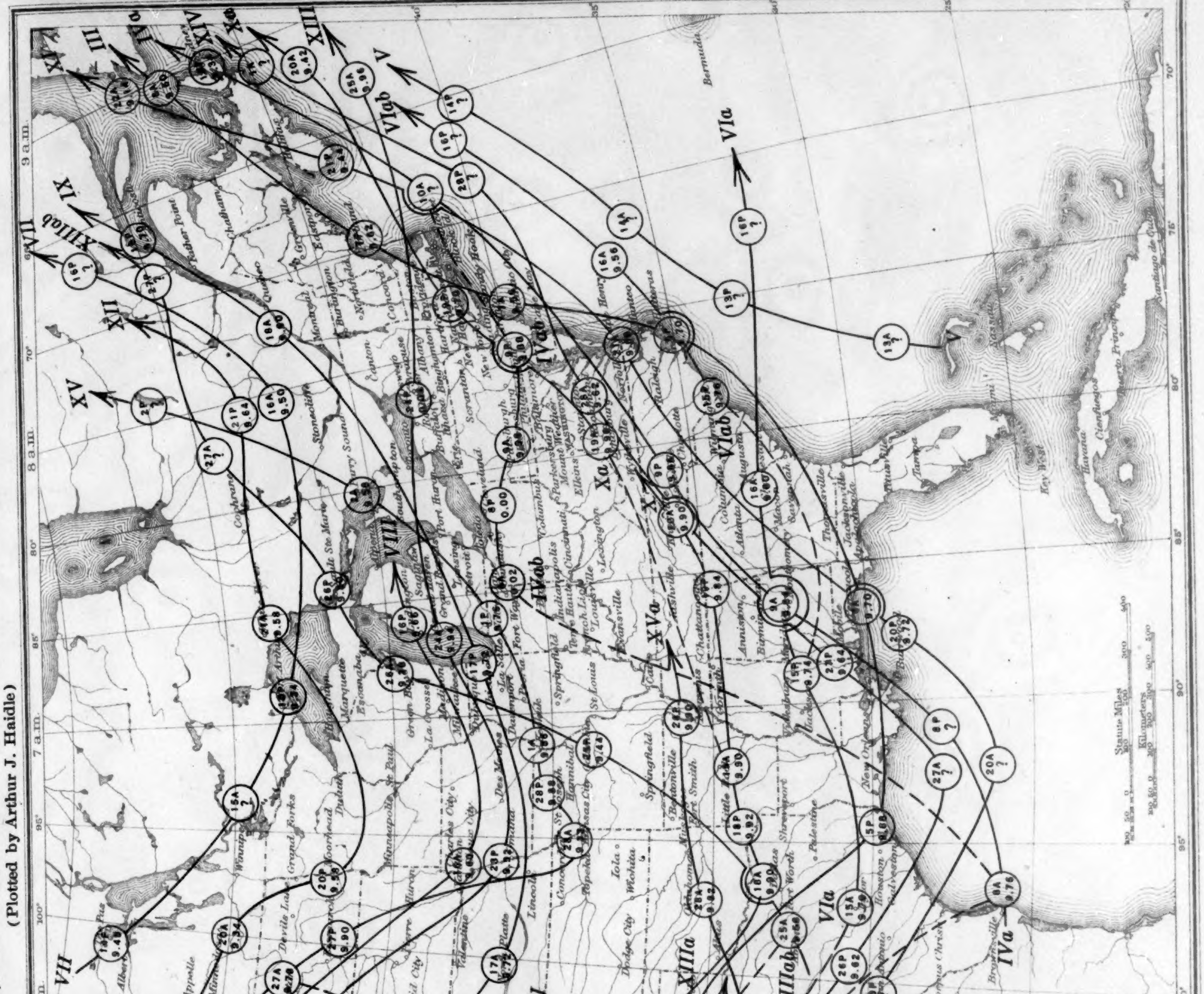

Chart III. Tracks of Centers of Cyclones, February, 1929. (Inset) Change in Mean Pressure from Preceding Month
(Plotted by Arthur J. Haidle)

Chart IV. Percentage of Clear Sky between Sunrise and Sunset, February, 1929

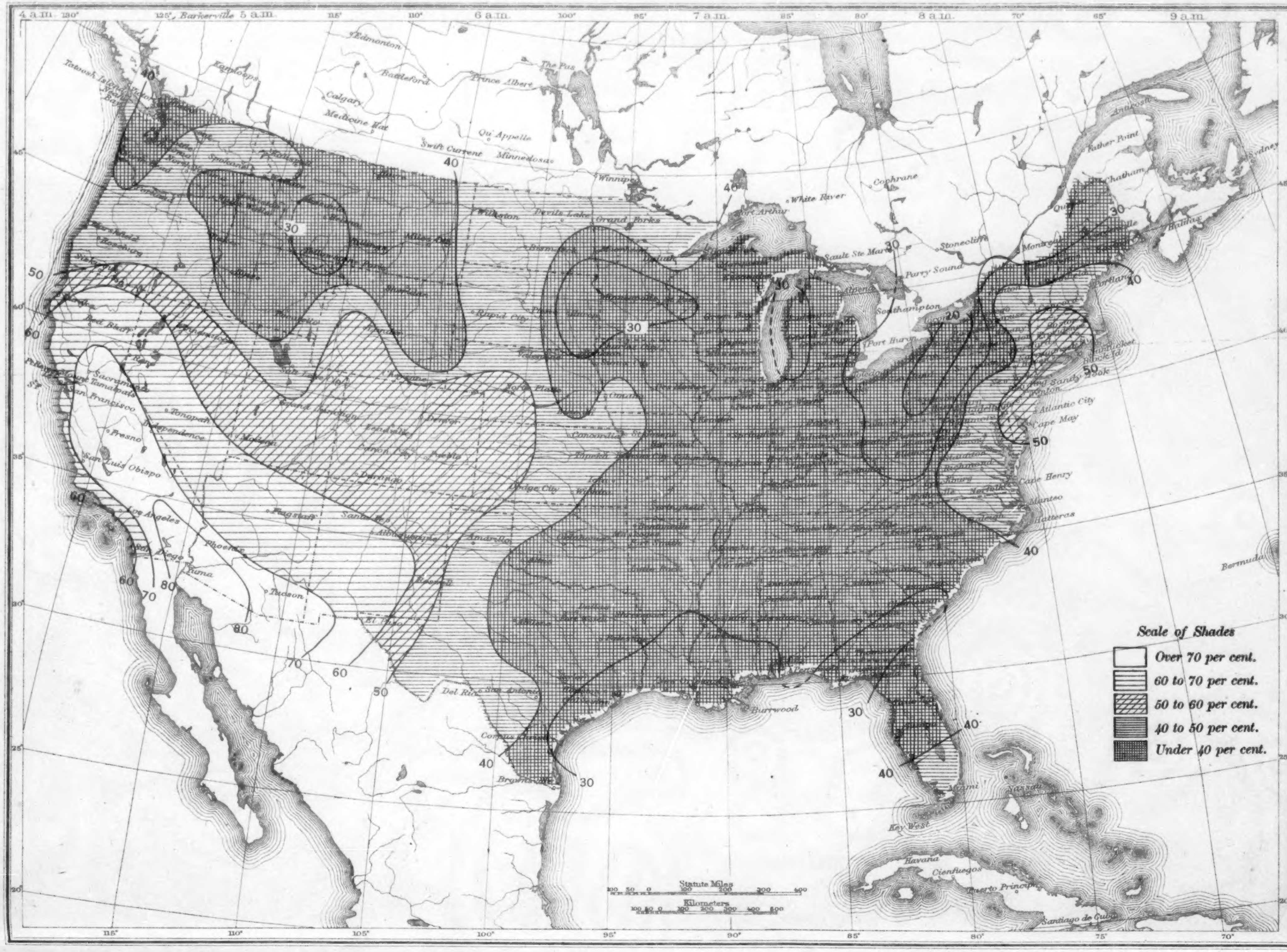

Chart V. Total Precipitation, Inches, February, 1929. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, February, 1929. (Inset) Departure of Precipitation from Normal

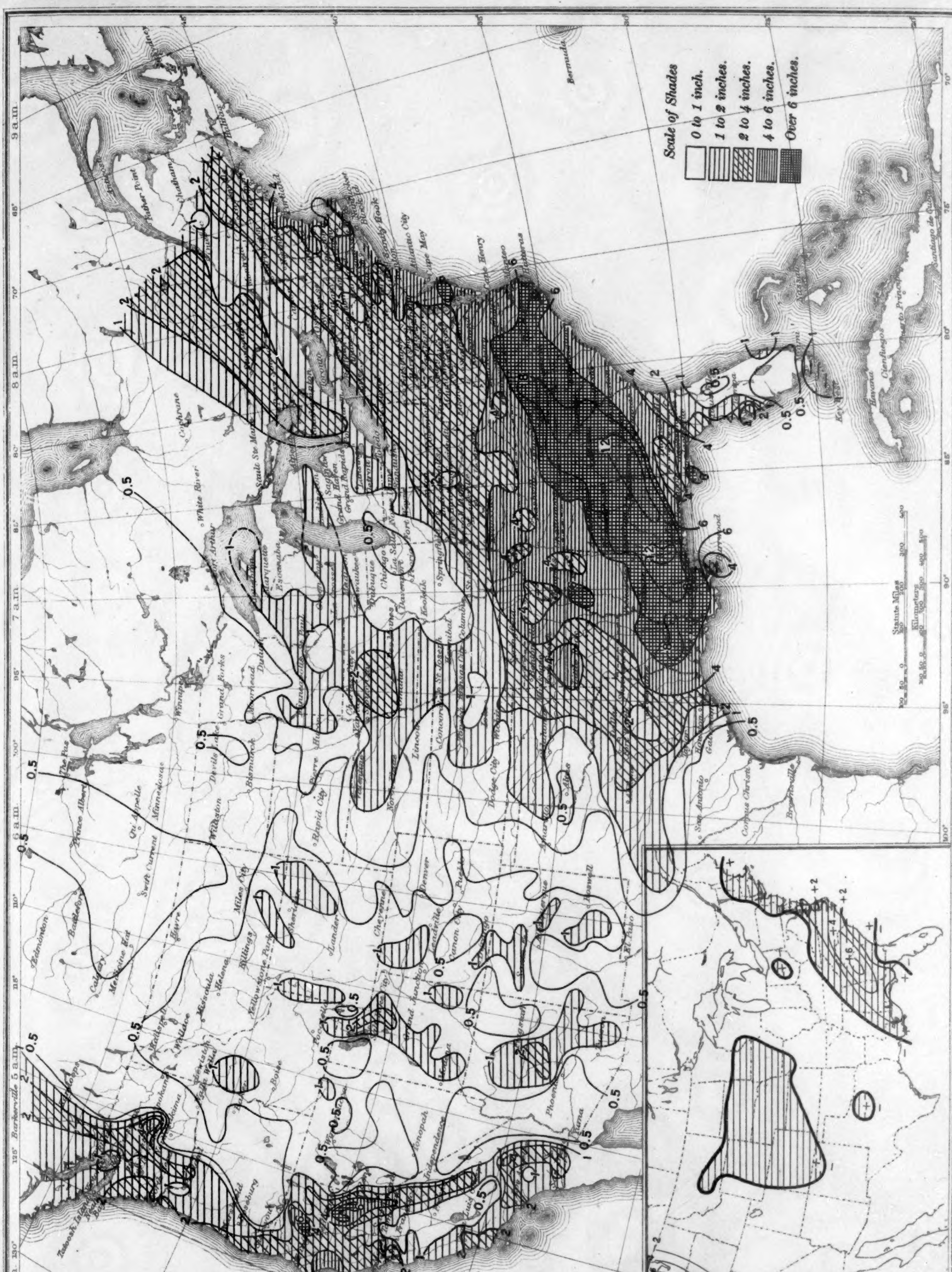

Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, February, 1929

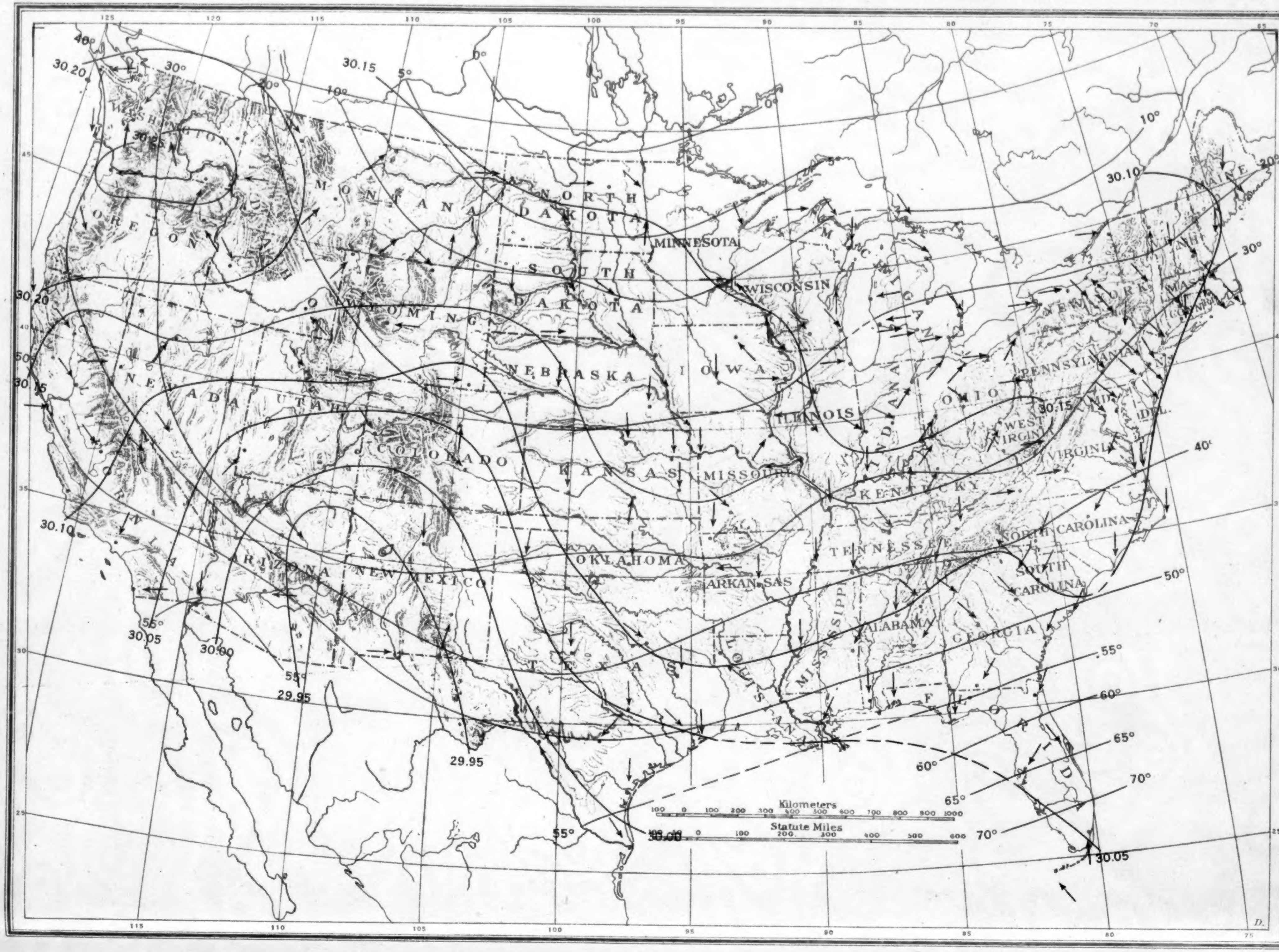

Chart VII. Total Snowfall, Inches, February, 1929. (Inset) Depth of Snow on Ground at end of Month

Chart VII. Total Snowfall, Inches, February, 1929. (Inset) Depth of Snow on Ground at end of Month

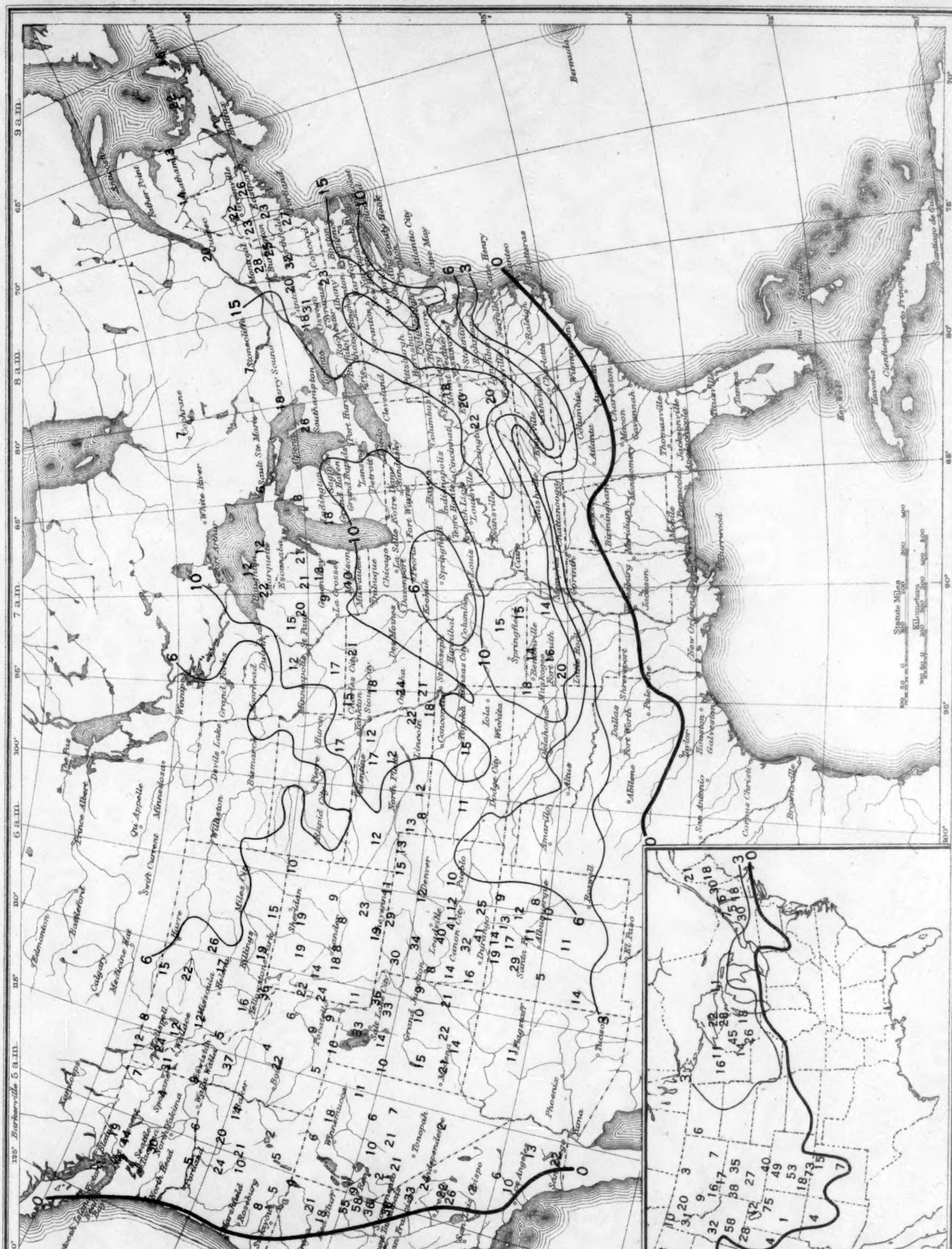

Chart VIII. Weather Map of North Atlantic Ocean, February 15, 1929

(Plotted by F. A. Young)

Chart VIII. Weather Map of North Atlantic Ocean, February 15, 1929
(Plotted by F. A. Young)

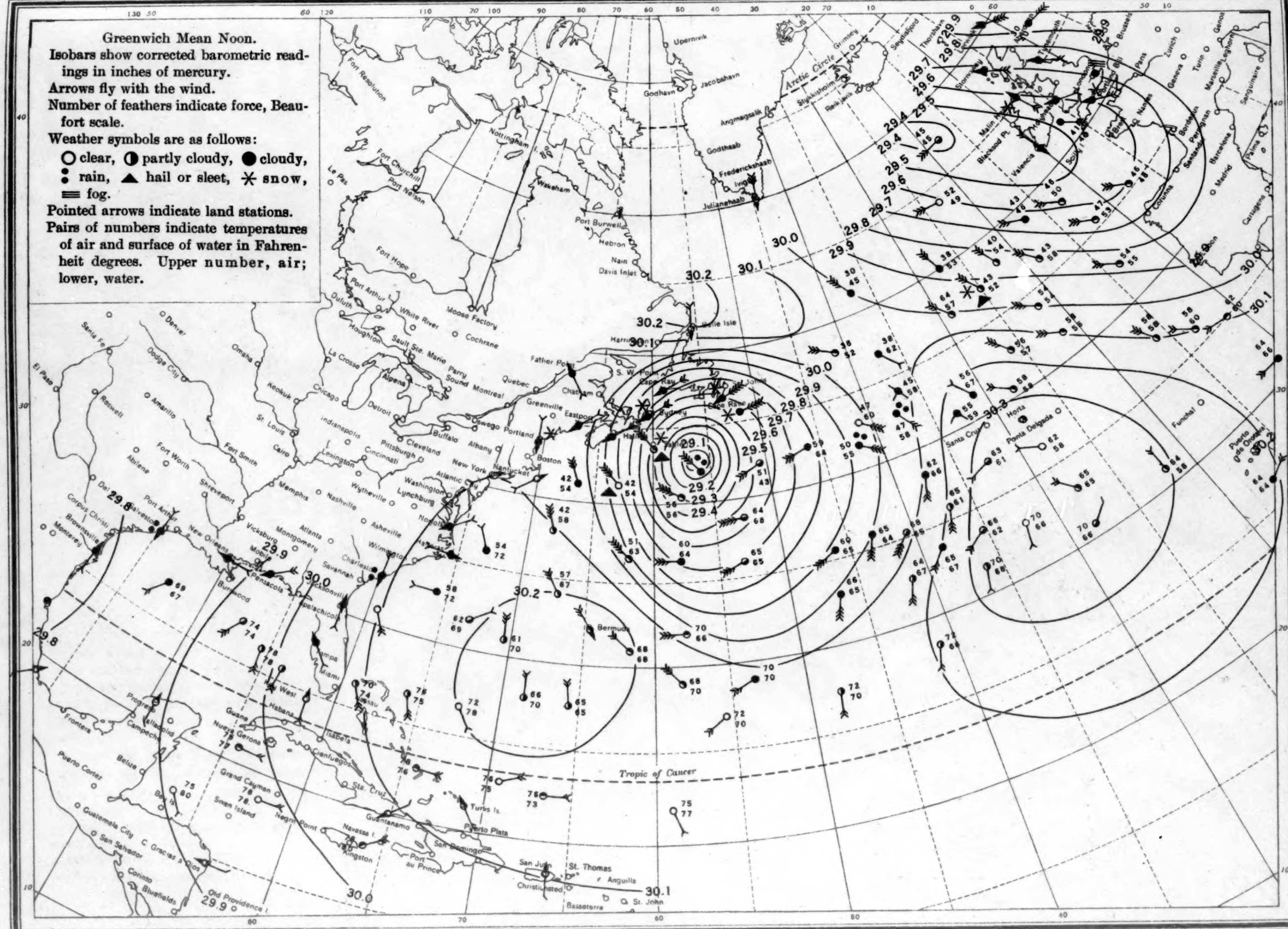

Chart IX. Weather Map of North Atlantic Ocean, February 16, 1929

(Plotted by F. A. Young)

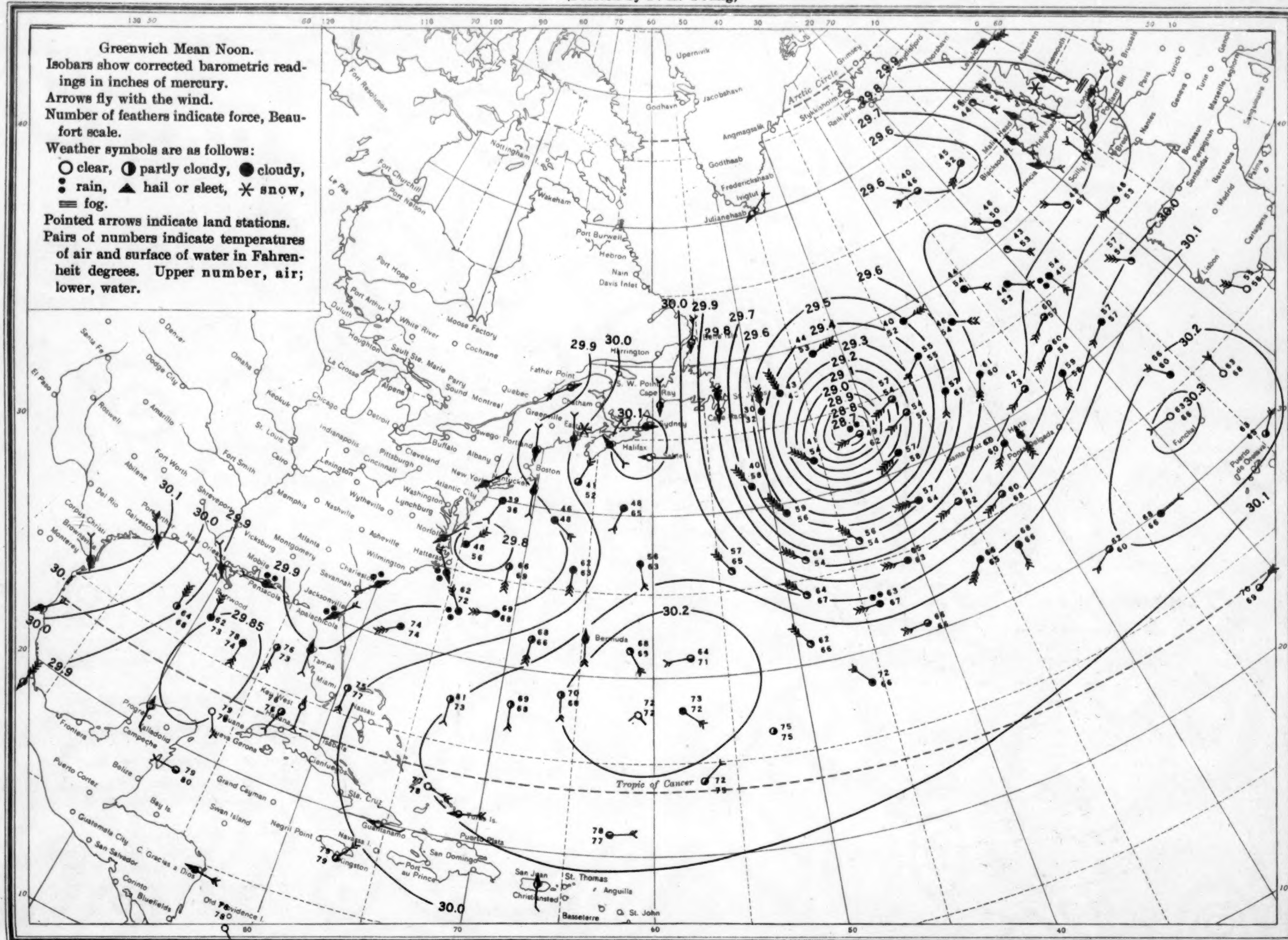

Chart X. Weather Map of North Atlantic Ocean, February 17, 1929

(Plotted by F. A. Young)

Chart X. Weather Map of North Atlantic Ocean, February 17, 1929
(Plotted by F. A. Young)

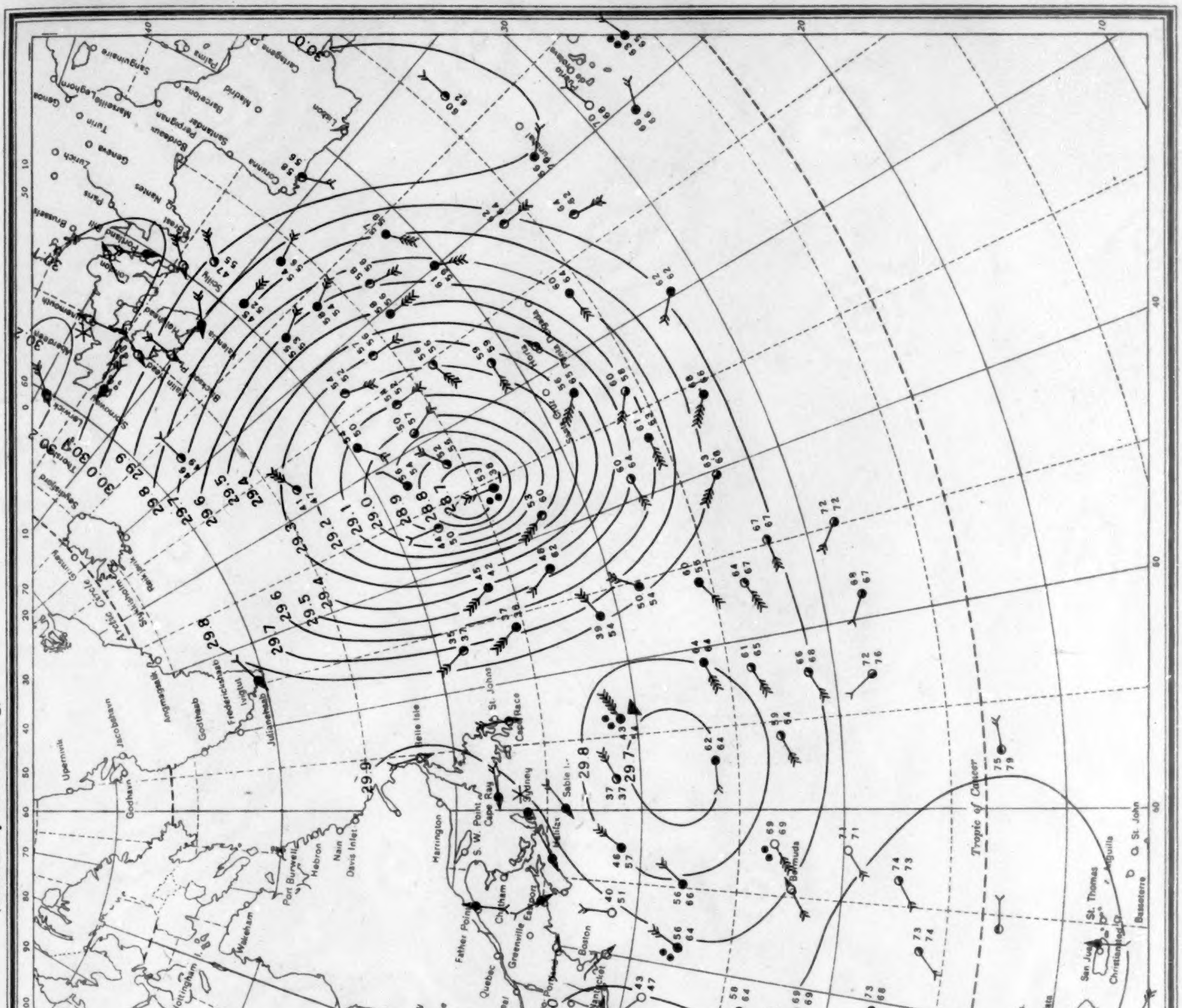

Chart XI. Weather Map of North Atlantic Ocean, February 18, 1929

(Plotted by F. A. Young)